Draft Methodology for Calculation of GHG emission avoidance

First Call for proposals under the Innovation Fund

Discussion Paper in support of Technical Workshop 5 February 2020

Date: 28 January 2020

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Executive Summary

Innovation Fund (IF) aims at supporting the ETS industrial and power sectors to meet the innovation and investment challenges of the low-carbon transition.

This discussion paper summarises the potential methodologies for estimating GHG emission avoidance of innovative projects eligible for IF funding, in the preparation for the first call for proposals to be issued in June 2020.

It has been written specifically to help experts attending a technical workshop on GHG avoidance methodologies to be held on 5 February 2020 in Brussels, to understand and challenge the practical application, workability and utility of these methodologies. Questions are raised at various points in the paper to initiate the discussions which will be continued at the workshop.

As general rule, the emissions savings from projects applying for funding under the IF will be the difference between the emissions from the project activity and a reference scenario (e.g. emission from an industrial plant meeting the ETS benchmark).

The complexity of the quantification of the emissions vary depending on how broad the boundaries of the project and reference scenarios are set, and on the choice of emission factors.

This document describes pros and cons of different approaches for estimating GHG savings for various sectors to support discussion and decision on the most sensible approach to be adopted under the IF, and potential methodologies to be adopted.

Key challenges and issues that are to be agreed upon at the Technical Workshop include the trade-off between precision of emissions and ease of quantification, monitoring and reporting, the broad variety of projects scenarios, reference technologies and regions that the IF will comprise, and alignment with other legal requirements.

The feedback and recommendations on how to refine these draft methodologies will inform the drafting of the first call guidance document.

1 Introduction

1.1 Scope

This document describes potential approaches to quantify the greenhouse gas (GHG) emissions saved or avoided by innovative projects eligible for Innovation Fund (IF) funding:

- low-carbon projects in energy-intensive industries, including substitute products and carbon capture and utilisation (CCU);
- carbon capture and geological storage (CCS);
- renewable energy (RES) projects;
- energy storage projects
- production of components for innovative RES and energy storage technologies.

1.2 Main principle

As general rule, the emissions savings from projects applying for funding under the Innovation Fund will be the difference between the emissions from the project activity, and the emissions that would occur in a reference scenario.

For instance, the emissions savings due to the generation of renewable energy would be calculated by deducting the project emissions from those occurring for the generation of the same amount of energy using the conventional technology (reference scenario). However, as detailed later, the emissions changes associated with changes in inputs and other products of the process also need to be considered by balancing them in the reference scenario.

1.3 Use of the methodology

This methodology will be used by potential applicants to calculate their potential GHG emission avoidance over the first 10 years of operation. The calculation will be then checked by independent evaluators and will be the basis of the scoring of the selection criterion “effectiveness of GHG emission avoidance.” The projected GHG emissions avoided will then be used as main performance metrics during project monitoring and will thus be the basis of disbursements of the Innovation Fund grants. Projects that reach at least 75% of the projected emissions avoided over the first 3 to 10 years of operation[1] will receive 100% of the grant.

Given that projects under the first IF call may start operating in the period 2022-2027, the ex-ante calculation of a project’s GHG avoidance within the first 10 years of operation will require to use assumptions about the future conditions in the period 2022-2037. For the general framework, it will be assumed that the future EU’s energy system will develop in line with current EU regulation, in particular with the EU’s Clean Energy for All Europeans Package including the updated targets for energy efficiency and renewable energy shares as well as with the national energy and climate plans (NECPs) submitted by Member States. It is also assumed that the expansion of energy grids will follow the Ten-Year Network Development Plans.

In addition, a further possibility to use the methodology is in a ‘2050 world’ calculation, which will be an input for the degree of innovation selection criterion.

Project proponents will be provided with clear guidance on the exact assumptions to be used during the application procedure as well as during the monitoring, reporting and verification (MRV) period. Furthermore, the methodologies to be discussed in the workshop will have to make sure that the ex-ante assessment provides a robust estimate of the GHG emission avoidance so that project proponents will be able to meet the forecasted GHG emission avoidance during operation according to MRV procedures.

1.4 Objective of the workshop

The objective of the technical workshop is to check whether the methodologies proposed are sufficiently robust to reflect the actual change in emissions between reference and project scenarios, but that they are not excessively complicated to discourage applicants or generate disproportionate administrative burden.

In particular, the following questions will be discussed:

[1] The exact period for monitoring will be set in the project grant agreement based on the project proposal and after agreement of the Commission.

- What is best for accuracy of emissions?
- What is sensible to simplify without prejudice to quality?
- What is not recommended to omit or simplify?
- Do the methodologies cover all possible project types eligible to apply for IF funding?
- Are the data required for the calculations easily available and can independent evaluators check them?
- Will it be possible to monitor performance during lifetime of the projects without too big administrative burden and with sufficient accuracy?

2 Potential approaches for quantification

2.1 Low carbon projects in energy-intensive industry, including those with carbon capture and utilisation

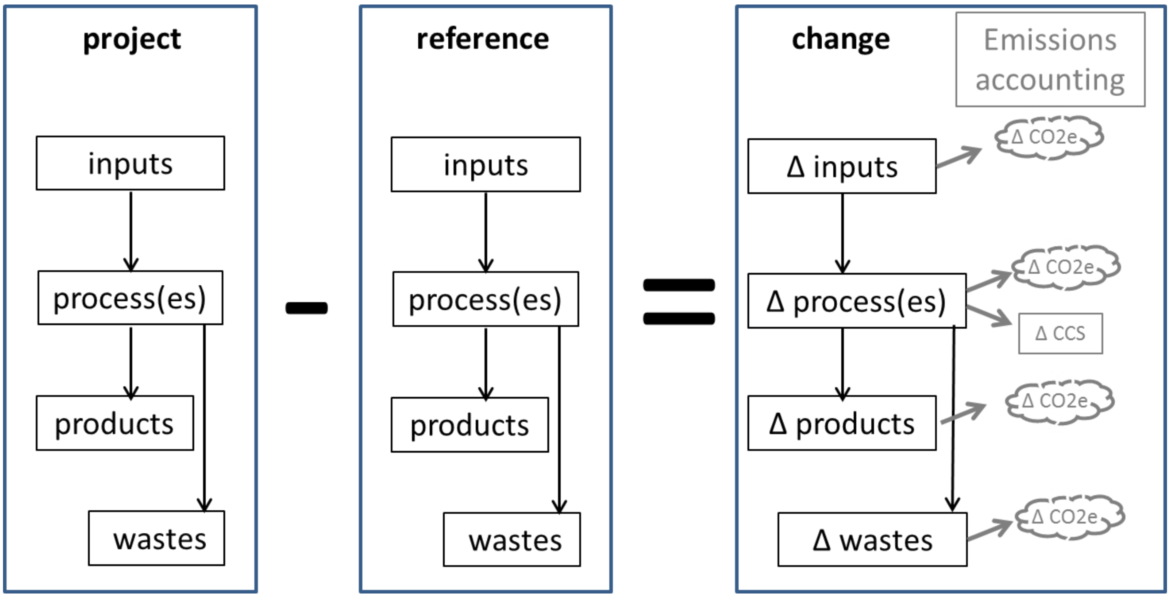
This part will deal with the approach to estimate GHG emission avoidance in projects falling in the energy-intensive industry sectors covered by Annex I of the EU Emissions Trading System (ETS) Directive, including projects for substitute products for those products otherwise produced in these sectors. Carbon capture and utilisation projects will also use this methodology, whereas carbon capture and storage is dealt with in section 2.2.

2.1.1 Suggested methodologies

The emissions from a project applying for the IF are evaluated by comparing a scenario including the proposed project, with a reference scenario without the project, as illustrated in Figure 2.1.

The change in emissions attributed to the project, i.e. the emissions avoided by the project, are those of the project scenario minus those of the reference scenario. Thus, if parts of the scenarios are identical, there is no need to include them in the emissions calculation. However, the scenarios should include all processes the emissions of which may be changed by the project.

Figure 2.1 Schematic of GHG savings related to low carbon projects



Thus, if a project involves construction of a new plant, the reference scenario includes the alternative process(es) that provide the same or equivalent function(s)[2] in the absence of the project.

[2] An “equivalent function” is usually an identical product made in the conventional way. However, if the new product does not have an identical equivalent, it would be the conventional product(s) that would fulfil the same function.

The change in emissions attributed to the project, ΔE(project) is the sum of the change in its component parts, each of which may be positive or negative:

ΔE(project) = ΔE(inputs) + ΔE(processes) + ΔE(products) + ΔE(wastes)

It is only for convenience of our description that the scenarios are broken down into inputs, processes and products. As long as the products balance between the project and reference scenarios, the result will be the same whether, for example, emissions are represented as an “input” or as additional process at the “processes” stage to make that input.

2.1.1.2 ΔE(process(es))

In the case of a project consisting of a new plant, the project scenario contains the plant, whilst the reference scenario contains the processes that are needed to provide the same principal products in a conventional plant.

In the case of an innovative project to modify an existing plant, the project scenario contains the modified plant and the reference scenario contains the unmodified plant provided that the modified plant has emissions less than or equal to an installation reaching the ETS benchmark. The objective is to avoid projects “locking in” high-emissions plants that do not reach the ETS baseline. Therefore, if the modified plant does not achieve the benchmark emissions reduction, the project will not be considered.

In the case of an innovative project for a new plant falling into an ETS category, the reference plant will be a plant defined able to meet the ETS benchmark.

Simplifying exclusions

Emissions from the so-called “grey energies” involved in constructing plant and equipment shall not be counted/included, nor will emissions from changes in land use from non-biological sourced processes, unless the Commission has grounds for considering that either can be unusually significant for a particular process (compared to its output)[3].

No account will be taken of changes in emissions attributed to employees or dependents.

Emissions savings from carbon capture and geological storage (CCS)

If an IF project in this category saves emissions partly due to permanently storing carbon dioxide in accordance with Directive 2009/31/EC on the geological storage of carbon dioxide, this may be credited to the products of the process as a reduction in emissions, although any emissions associated with the storage operation will also need to be taken into account. See section 2.2 for details on the methodology to account for emissions from projects that reduce emission only through CCS.

[3] This is in line with the methodology for emissions from biofuels, biogas and bioenergy. However, land use change emissions and indirect land use change emissions are generally much smaller than in the case of biofuels, and “grey energies” are generally a small part of total emissions for large industrial plants. Nevertheless, bearing in mind the unknowable range of possible processes that could be involved in IF, it is safer to protect against possible land-intensive solutions or processes that require particularly emissions-intensive capital equipment. Indicatively, liquid transport fuel made from wind-electricity would have “grey emissions” from turbine manufacture (and maintenance) of roughly 8gCO2e/MJ, and about 22g/MJ if made using PV. (Calculation assumes 40% efficiency of the conversion from electricity to road fuel, and standard emissions for fuel distribution.).

Emissions savings from CO_2 capture and use; interaction with ETS

It is implicit in the "project – reference" methodology that If additional CO2, that was either in the atmosphere or about to enter the atmosphere, is captured in an IF process and incorporated into a product, the captured CO2 is accounted as a negative emission in the emissions calculation of the project[4]. Any emissions involved in the capturing process will be part of the overall process emissions. To avoid double counting where a fuel is made incorporating that carbon, no adjustment is made to its emissions when combusted in use.

If CO2 is bought on the industrial CO2 market, or transported in from another plant, and thus treated as an input, a similar credit is applied in calculating the emissions intensity of that CO2 input. Thus, the CO2 credit is calculated by incorporating the CO2-capture plant into the project scenario and the same plant without CO2 capture in the reference scenario.

No credit is applied in the case that fossil fuel was burnt for the sole purpose of making the CO2 (but that would not normally be a commercial proposition).

However, to avoid double counting under different legislations, if the GHG benefit for capturing the CO2 is already claimed under another legal provision (such as ETS or revised Renewable Energy Directive[5] (REDII)), the CO2 credit cannot be claimed for the IF project unless the benefit under the other legal provision is surrendered. This is to ensure that the user of the CO2 gets the credit for its capture, not the installation that captures it. That is because far more CO2 is being emitted, also in concentrated form, than is needed by industry. Therefore, an increase in the demand for industrial CO2 will lead to more CO2 capture, but increasing CO2 capture without increasing its usage will merely displace capture of CO2 by another installation, with no saving of CO2 emissions.

2.1.1.3 ΔE(inputs)

This is the change in emissions arising from changes in all inputs. “Inputs” includes feedstocks, electricity, process fuels, process chemicals etc., as well as CO2 (for carbon capture and utilisation, CCU). The emissions of each input are the change in the amount of input times its GHG intensity. The only inputs that need to be considered are ones whose amounts change between the project scenario and the reference scenario.

RIGID inputs

If the input has a fixed supply, then it is considered “rigid”: it can only be supplied to a new project by diverting it from another use. Its emissions intensity then considers the impact of diverting it from its existing use. Those impacts include any changes in transport, storage or processing of the inputs before they arrive at the process. The emissions intensity may be negative (i.e., avoidance of GHG emission) if the input was releasing emissions in its existing use, or positive (creating GHG emissions) if it was saving emissions in its existing use.

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[4] Similarly, any CO2 capture and use in the reference scenario must also be taken into account in deciding what CO2 capture in the project is additional.

[5] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources

Examples of rigid inputs include:

- municipal waste, used plastics, used lubricating oil;
- intermediate streams from existing processes: e.g. blast furnace gas, black liquor;
- unused process heat taken from an existing process;
- minor by-products of existing processes, where the ratio of the outputs cannot be changed significantly. (to answer the question "how minor?", see Annex A2.4). An example of this type of rigid input is hydrogen from an existing chlor-alkali process.

Example: municipal waste

The emissions intensity takes into account its existing fate, as well as the emissions associated with any additional treatment and transport. For example, if its existing fate was incineration without energy recovery, the emissions from the incineration are avoided, and this means the emissions attributed to the waste are negative[6]. If it is diverted from landfill, the carbon emissions attributed to it at the point of collection shall also be negative and equal to the emissions from the landfill in CO2 equivalents[7], because although landfill sequesters part of the carbon, it is not desirable to encourage landfill for other environmental reasons.

By contrast, if for example the claimed "waste" input was being burnt to provide electricity, the emissions attributed to it as an input to a fuel process would include the emissions associated with replacing the lost electricity generation. The emission intensity attributed to the lost electricity is the same as for electricity inputs, as specified in the "elastic inputs" section, below.

If an innovative process produces a fuel from mixed municipal waste, part of the fuel would qualify as biofuel and qualify for incentives under the Renewable Energy Directive. The calculation of emissions savings under the IF fund will therefore exclude that part of the production.

Example: "waste heat" as an input

A process may take heat from another existing process. In this case, the emissions attributed to the heat input shall be the increase in the emissions of the other process associated with the heat export. Thus, if the heat is truly "waste heat", it would be considered free of emissions. On the other hand, if extra fuel needs to be burnt to replace the heat in the existing process, its emissions intensity is the emissions from burning that extra fuel.

Example: industrial off-gas as an input

For example, if a stream of industrial off-gas is diverted from a simple fate such as flaring, flaring and release of the CO2 to the atmosphere, the emission attributed to that input is negative; equal to the existing CO2 release. Conversely, if the existing use of the gas is only electricity generation, the emissions attributed to that input are positive, and equals the emission involved in replacing the electricity.

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[6] i.e. avoiding the original fate saves emissions, so there is a CO2 credit for its novel use

[7] Landfill in general generates methane, which has a higher greenhouse gas intensity than CO2. However, almost all the methane comes from the bio-content of the waste. So if a fuel is produced, the methane reduction credit should be attributed to the biofuel component that would qualify as a biofuel under RED.

However, if the industrial off-gas produces also process heat, the use of which is integrated in the existing plant, the calculation is probably more complex, involving plant modelling. Then, the existing plant should be incorporated into the “process” stage of the reference scenario, and its modified version into the “process” stage of the “project” scenario.

Example: geological CO2

Similarly, if for example a geological source of CO2 is used for a CCU process, its capture will be attributed an emissions credit only if it was being released naturally anyway. Conversely, if additional geological CO2 is released due to the innovative project, it should be accounted as (positive) emission.

Waste Hierarchy

As we consider the emissions saved by the alternative fate of a claimed “waste” used as an input, if it would otherwise be mechanically recycled (e.g. more plastic waste being recycled to replace new plastic as a material), it will be attributed significant emissions. The waste hierarchy puts top priority on mechanical recycling because that is thought generally to save the most emissions.

Even if a claimed "waste" is not being mechanically recycled now, it could get mechanically recycled in the future, because member states need to meet future recycling targets. To help ensure that the use of the waste for fuel production does not prevent future improvements in mechanical recycling, waste that is converted to a different product in an IF project shall not be counted towards Member States’ targets for mechanical recycling.

ELASTIC inputs

If the supply of the input varies in order to meet the change in the demand, then the input is considered “elastic”, and its GHG intensity is found from **the emissions involved in supplying the extra input**. The exact definition of an elastic input is given in the Annex A2.6.

Minor elastic inputs

If an elastic input is responsible for less than 5% of the total emissions attributed to inputs and the process, it is classed as a minor input, and its emissions intensity may be taken from reference literature, according to the hierarchy in the Annex A2.4. Inputs may be ignored that *collectively* contribute less than 3% to those total emissions[8].

Fuels Inputs

The emissions intensity assumed for fossil fuel inputs to processes must be taken from reference sources according to the hierarchy in the Annex A2.5. In practice, this means most of them will be those assumed in REDII.

[8] Clearly, a preliminary calculation has to be done with the reference emissions, in order to determine whether the 5% threshold is breached. But in many cases the inputs are so small (e.g. lubricating grease) that they obviously will have negligible impact.

Inputs from new sources

If an input will come from a new plant or source set up for the purpose, that plant shall be incorporated in the "processes" part of the project scenario. The same applies if a plant is expressly expanded to fulfil the increased demand, (and of course the unmodified plant will then go into the reference scenario).

Major elastic inputs: the incremental principle

If the input does not qualify as "minor", its emissions intensity is the extra emissions caused by increasing the output of the accessible supply plants to meet the extra demand. In other words, they are the marginal supply emissions. For example, the emissions attributed to hydrogen taken from a refinery would be calculated from the marginal increase in refinery emissions caused by exporting the hydrogen.

If the input is bought on the market, and several types of plants supply the product that is used as an input, the ones with a rigid output are not considered, and the emissions are estimated for the type of plant that will act as the "swing" supplier.

> *Again, take the supply of hydrogen as an example, but in the case if it is bought in cylinders from the industrial gases market. The extra hydrogen supply to the market cannot come from chlor-alkali plants that are already supplying the market, because they are a rigid source, producing hydrogen in a fixed ratio to their main products. Under the present market conditions, the "swing" supply comes from steam-reforming of natural gas (an elastic source).*

Where an elastic input is the main output (in terms of value) of a supply chain, its emissions intensity is the sum of emissions for all the steps in its production, from extraction, transport, storage and processing of primary raw materials, through any intermediate steps of transportation, storage and processing, to manufacture and transport of the product.

Attribution of emissions between co-products in the supply of elastic inputs

It is only necessary to consider attribution of emissions between products where those products are used as elastic inputs of an IF project. That is because the calculation of emissions intensity for a rigid input is based on the elastic product that replaces it in its existing use.

An elastic input of an IF project is usually the product of another process. But that supply process may produce several co-products. Then it is necessary to attribute emissions between the co-products.

For the purposes of the calculation of attribution of emissions to co-products, the emissions to be shared shall be all emissions that take place up to and including the process step at which the co-products are produced. Obviously, if an input to the process is itself a co-product of another process, the sharing out of emissions at the other process must be done first to establish the emissions to be attributed to the input.

ISO 14044 (2006) provides a framework for such an attribution, although it is often misinterpreted. The annex A2.5 explains why following ISO standards correctly leads to the following rules for calculating the emissions intensities for the supply of elastic inputs that are co-products of another process.

- The calculation shall follow the flow chart shown in the annex A2.5
- In the flow chart "allocation by physical causality" at the second level requires analysis showing the emissions consequences of changing the output of the product

without changing the output of co-products, and will generally require process modelling.

- At the third level, allocation shall generally be made by the economic value of the co-products. Any other choice needs to be clearly justified in terms of how the chosen allocation key describes the "cause of the limit" of production.

Renewable electricity inputs

Electricity inputs are only considered renewable if they are additional to the renewable electricity that would be consumed anyway. The conditions in the REDII will apply, in particular:

REDII Paragraph 90:

The Commission should develop, by means of delegated acts, a reliable Union methodology to be applied where such electricity is taken from the grid. That methodology should ensure that there is a ***temporal and geographical correlation*** *between the electricity production unit with which the producer has a* ***bilateral renewables power purchase agreement and the fuel production****. For example, renewable fuels of non-biological origin cannot be counted as fully renewable if they are produced when the contracted renewable generation unit is not generating electricity. Another example is the case of electricity grid congestion, where fuels can be counted as fully renewable only when both the electricity generation and the fuel production plants are located on the same side in respect of the congestion. Furthermore, there should be an* ***element of additionality****, meaning that the fuel producer is* ***adding to the renewable deployment*** *or* ***to the financing of renewable energy****."*

REDII Article 27.3:

However, electricity obtained from ***direct connection*** *to an installation generating renewable electricity may be fully counted as renewable electricity where it is used for the production of renewable liquid and gaseous transport fuels of non-biological origin, provided that the installation: (a)* ***comes into operation after, or at the same time as, the installation producing the renewable liquid and gaseous transport fuels of non-biological origin****; and (b)* ***is not connected to the grid*** *or is* ***connected to the grid but evidence can be provided that the electricity concerned has been supplied without taking electricity from the grid****. Electricity that has been taken from the grid may be counted as fully renewable provided that it is produced exclusively from renewable sources and the renewable properties and other appropriate criteria have been demonstrated, ensuring that the renewable properties of that electricity are claimed only once and only in one end-use sector.*

The Commission will further elaborate the additionality rules in a delegated act to be adopted by the end of 2021. However, the rules for the first call of the IF are needed earlier than that, so they may differ from the final rules adopted for REDII. Clearly, the existing Guarantees of Origin scheme does not meet the requirements of the REDII.

Other schemes such as "GO+" or Power Purchase Agreements need to be adapted[9], so that they reach the requirements set out in REDII, also considering the need to avoid creating more grid congestion. If such additional renewable electricity comes from bioelectricity, the emissions are taken or calculated from annex VI of the REDII.

Grid electricity inputs

Inputs of grid-electricity to IF projects that do not qualify as renewable according to the provisions above, shall be attributed the average of two emissions intensities:

- The time-averaged greenhouse gas intensity of the electricity consumed in the country of the plant.
- The time-averaged greenhouse gas intensity of the electricity averaged for all EU (see Annex A2.3).

Pragmatically, this provides an incentive to avoid siting plants in countries with high grid emissions, but also avoids projects under the Innovation Fund, preventing the decarbonisation of the EU electricity grid by siting them solely in Member States with very low GHG intensity grids.

All expandable sources of renewable electricity are intermittent. The only renewable source that can be switched on and off without wasting resources is dam hydroelectricity provided generating capacity exceeds the average water flow available. So, when abundant wind and solar electricity are available, hydro resources can be conserved, to be used when the wind stops blowing and the sun stops shining.

If Europe is to decarbonise its electricity production, all available EU and EFTA reservoir-hydro capacity will be required to provide low-carbon electricity when the supply of wind and solar cannot satisfy demand. This grid-balancing function saves far more emissions than using hydro-power for electrofuels. For example, replacing 1GJ of liquid fuel typically could require 2.6 GJ of electricity, whereas using those 2.6 GJ instead for backing-up intermittent wind or solar electricity, would save about 7 GJ of fossil fuel combustion. So it achieves roughly 7 times more emissions savings as a back-up, as well as helping the full decarbonisation goal.

Future scenarios for grid electricity

The GHG intensity of EU grid electricity is projected to fall, in line with the EU's Clean energy for all Europeans package[10], and the draft national energy and climate plans (NECPs) submitted by Member States[11]. This needs to be considered in estimating future GHG savings by projects submitted to the IF.

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9 See for example the discussion at https://theicct.org/publications/cerulogy-renewable-electrons-20191209. There, the discussion deals with additionality of RE; however, to satisfy REDII, it is also necessary to avoid adding to grid congestion.

10 https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/clean-energy-all-europeans

11 https://ec.europa.eu/energy/en/topics/energy-strategy-and-energy-union/governance-energy-union/national-energy-climate-plans

There are two main options for the future GHG intensity inputs: using a yearly GHG intensity input linked to the planned years of operation or simplifying it to the 2030 forecasted value. The former option would be the more accurate one for energy storage projects (see 2.4). In order to simplify calculations for industry projects, the expected 2030 GHG intensity of the grid can be used.

To enable this, the Commission will estimate the average GHG intensity of grid electricity consumed by each Member States in 2030, as well as an EU-average value. The calculation will build on the scenarios by the PRIMES model already published in technical report on EUCO3232.5 scenario[12].

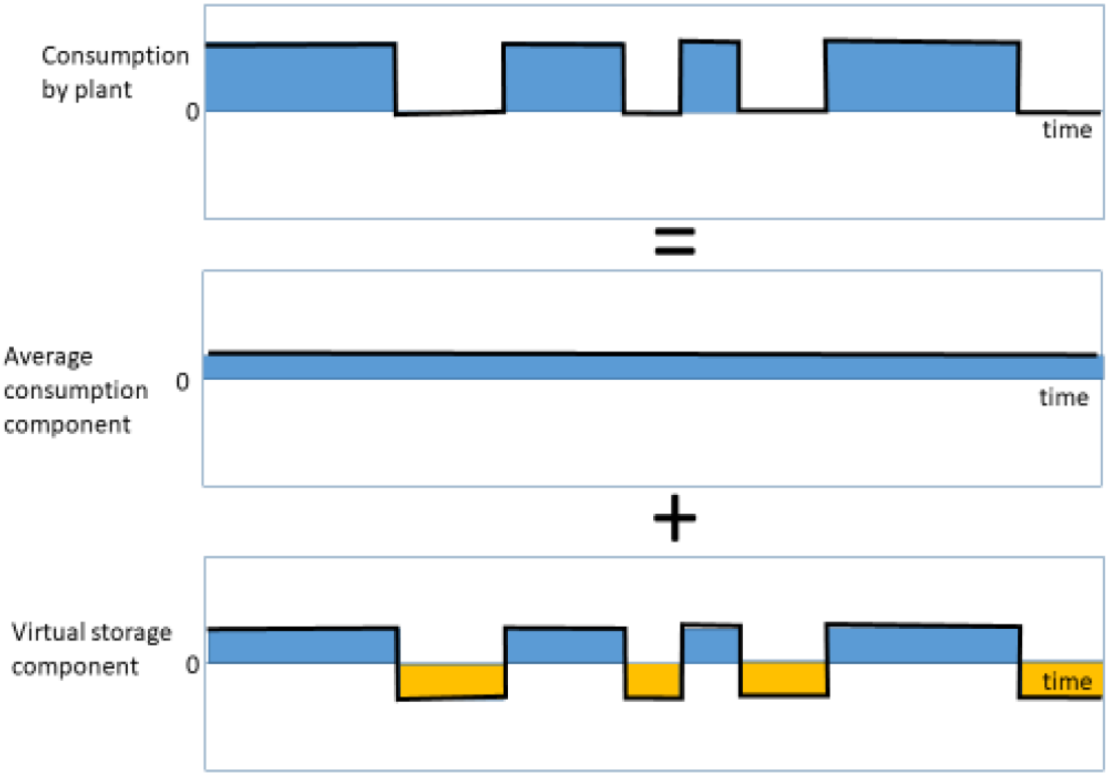
A further calculation would be undertaken for the '2050 world' where the GHG intensity of the grid is expected to be zero. This calculation will be used as an input to the degree of innovation selection criterion.

Lowering grid electricity emissions by timing plant operation

Even without any certification or contracts to use additional renewable electricity, a plant using electricity (such as an electrolyser) can reduce the emissions of its electricity supply by operating only at times when the marginal emissions of the electricity supply are below a threshold. This demand management will become more important in the future as the grid accommodates increasing fractions of intermittent wind and solar electricity. It helps grid stability in the same way as electricity storage. In fact, one can resolve the time-dependent electricity demand into a storage component plus a constant average consumption, as indicated in the diagram below. Then the emissions benefit of the demand management can be calculated in the same way as a project to store electricity.

12 http://ec.europa.eu/energy/sites/ener/files/technical_note_on_the_euco3232_final_14062019.pdf

Figure 2.2 Calculation of emissions from projects using electricity when marginal emissions are low



2.1.1.4 ΔE(products and use)

If a project under IF does not change the products (or functions) of the process, no calculation is required. If the products are changed, one must calculate the emissions saved (or incurred) by the substitution. For example, a new plastic could save emissions by allowing bottles to be made thinner, with 1kg of the new plastic replacing 2kg of the old one.

Those calculations are done in the same way as process inputs, so they include any changes also in the transport, storage and distribution of the products. The calculations for transport should use the standard values used for the REDII calculations[13] where possible.

Similarly, new materials can save emissions in the use phase by increasing energy efficiency or reducing emissions during use. (For example, new fertilizers or agrochemicals could reduce nitrous oxide in the field, or innovative products could replace gases with higher global warming potential.) In estimating future emission savings during the use by customers, the size of the market needs to be estimated conservatively and with an uncertainty range.

<u>Vehicle efficiency</u>

Products of IF projects may cause substantial changes in vehicle efficiency: for example, hydrogen for fuel-cell cars. In order to account for this whilst keeping the fossil-fuel

[13] https://ec.europa.eu/jrc/en/publication/definition-input-data-assess-ghg-default-emissions-biofuels-eu-legislation.

comparator at 94 gCO2eq/MJfuel (the value in REDII), it is appropriate to apply a factor to the emissions attributed to fuels used exclusively in vehicles with electric power trains. For example, for a fuel-cell vehicle, the factor is the consumption (in MJ/km) of fuel by the average electric power train vehicle using the fuel compared with the average consumption of gasoline and diesel vehicles that fulfil the same function. Such a factor will only be applied where the Commission is convinced the effect is substantial, after considering submissions on a case-by-case basis.

2.1.1.5 ΔE(wastes and their treatment)

This section is not about wastes used as an input: that is covered in the “inputs” section. Instead, it is about accounting for changes in emissions because of the change in the nature of wastes produced by a process or at the end of the product life. For example, an innovative process may eliminate a waste stream that requires energy-intensive treatment. Or, an innovative product may be more suited for recycling or create less emissions during waste treatment than its predecessor. Obviously, if there is no change, no calculation is needed.

Key questions for discussion at the technical workshop:

- **Reference scenario:** The current proposal is that
  - the reference scenario for the 2030 calculation should incorporate the existing plant, PROVIDED that the as-modified plant attains the low emissions of the plant able to meet the applicable ETS benchmark.
  - the reference scenario for the 2050 calculation should be the applicable ETS benchmark plant.

- **GHG savings in the use phase:** Some projects claim GHG savings in the use or disposal phase of the products or plants that incorporate them (e.g. a system for recovering waste heat in industry). However, a plant proposing to use the innovation could claim the GHG improvement in ETS or even in an IF proposal. Is there a danger of the benefit being counted twice?

- **"Grey Emissions":** This means the emissions from the construction of the plant or devices (e.g. PV cells). In REDII these are neglected, because the REDII concentrates on refineries, where they are small compared to the GHG emitted in operation. The assumption also results in practically zero emissions for renewable electricity. The problem is then that there is no incentive to make efficient use of those energy sources, and can give false comparisons of GHG savings against alternative projects. For example, an electro-fuel process loses most of the energy in electricity in making it into a fuel (and the vehicle then loses most of the fuel energy in the engine, so this pathway is much less efficient than if the same electricity can be used in an electric vehicle). Indicatively, including "grey emissions" would give liquid transport fuel made from wind-electricity of roughly 8gCO2e/MJ, and about 22g/MJ if made using PV. (The calculation assumes 40% efficiency of the conversion from electricity to road fuel). That reduces reduces the GHG saving for PV-from almost 100% to 77%. Points to discuss:
  - How much extra administrative burden? Many LCAs do it already, but it is not in REDII.
  - Could a criterion for when to consider them (e.g., "only for PV and wind") be defined?

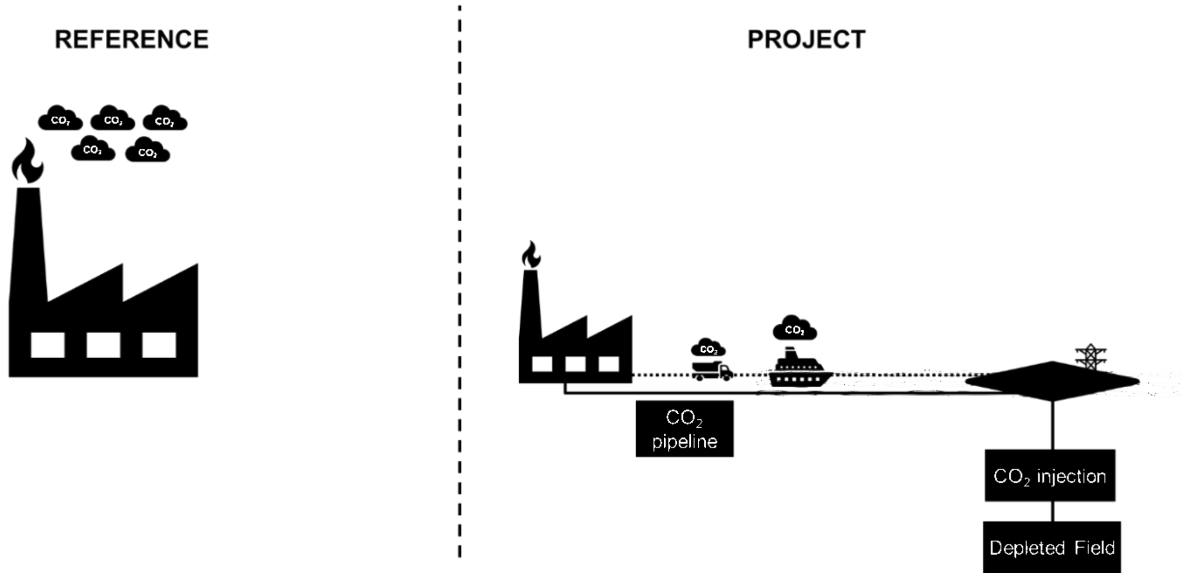
- **Recycling improvements:** Some proposals rely on future improvements in sorting for recycling (e.g. introducing a new type of plastic or refrigerant that must be recycled separately). Is that foreseeable?

2.2 Carbon Capture and Storage (CCS)

After exhaust gases are captured from large industrial processes and CO_2 is separated from it, the CO_2 will then be compressed, transported by road tanker, ship and/or pipeline and injected into a suitable storage site.

Figure 2.3 illustrates the key emissions sources involved in a CCS project.

Figure 2.3 Illustrative representation of emissions occurring in a conventional industry (Reference) and those being captured and stored (Project)



Under the ETS, emissions related to the CO_2 capture activity for the purposes of transport and geological storage_shall be quantified by operators according to Commission Implementing Regulation (EU) 2018/2066 of 19 December 2018 on the monitoring and reporting of greenhouse gas emissions.

Operators below shall consider at least the following potential emission sources for CO_2 when setting the boundaries of their installation:

- **Operator of a CO_2 capture activity for the purposes of transport and geological storage** (Annex IV Article 21)**:** CO_2 transferred to the capture installation; combustion and other associated activities at the installation that are related to the capture activity, including fuel and input material use.
- **Operator of a transport network of CO_2 by pipelines for geological storage** (Annex IV Article 22)**:** combustion and other processes at installations functionally connected to the transport network including booster stations; fugitive emissions from the transport network; vented emissions from the transport network; and emissions from leakage incidents in the transport network.
- **Operators of a geological storage of CO_2 activity** (Annex IV Article 23)**:** fuel use by associated booster stations and other combustion activities including on-site power plants; venting from injection or enhanced hydrocarbon recovery operations; fugitive emissions from injection; breakthrough CO_2 from enhanced hydrocarbon recovery operations; and leakage.

Monitoring and reporting of non-stationary activities are currently not required by the ETS.

Under NER 300, project proponents are required to provide an estimate of the total expected tonnes of CO_2 that will be stored annually and in total for the first 10 years of operation, which shall be calculated by subtracting the following emissions from the amount of CO_2 received:

- Fugitive emissions;
- Venting emissions pre-injection and from Enhanced Hydrocarbon Recovery;
- Any amount of CO_2 transferred to another installation pre-injection.

As with ETS, the NER 300 does not require applicants to quantify the emissions from fuel combustion in mobile sources used to transport the CO_2 to the location of the storage. However, NER300 does require some information related to transportation in CCS Projects for **knowledge-sharing** purposes. These include:

- Average and maximum monthly flow rates for transport and storage (litres per second, or kg per second)
- Average monthly availability (%) and hours operated of each step in value chain (i.e. capture, transport and storage)
- Impact of key impurities on transport performance
- Lessons learned and experiences in integration of and interfaces between capture, transport and storage
- Losses and leakage from CO_2 transport (% CO_2, or kg per MWh)

Transportation was also part of the **due diligence** questionnaire that CCS projects applying for NER300 funding went through. The questions focus on the level of knowledge of the project proponent on the technology associated with transport/ storage processes, as well as on the key risks associated with transportation during construction, project design, operation and decommissioning.

As transportation emissions would not occur in the absence of the CCS project, it could be beneficial for accuracy that these are quantified and subtracted from the GHG avoided through IF projects.

2.2.2 Approaches for estimating GHG savings

If accuracy of emissions is being sought, then a 'detailed' approach where emissions from the entire value chain of the project should be comprised within the boundaries of the calculation. This is to ensure that any changes in the ecosystem due to the project would be picked up, as the project may reduce emissions at production plant but increase elsewhere across the value chain. This is because *capturing CO_2 requires energy to power the equipment at the installation, and CO_2 will not necessarily be stored close to where it is captured, so it will have to be transported* creating emissions that would not occur in the absence of the project[14]. However, the level of effort involved might not justify the precision of the results[15].

In a simplified approach, emissions occurring to enable the capture, transport and storage would be disregarded and assume that the amount of CO_2 stored would equal the emissions avoided by the project for a given period. These 'disregarded' emissions are however fully considered under the ETS and projects would have to surrender CO2 allowances for them. The knowledge-sharing requirements would however reveal all these emissions that are omitted for sake of simplicity.

A middle-ground solution would be to deduct the most significant emissions sources occurring due to the CCS project following the ETS MRR requirements, and for which

[14] https://www.parliament.uk/documents/post/postpn335.pdf

[15] Although the activity values for most inputs, including transport by road or ship, can be derived from REDII standard values

activity/consumption data is still within the reach of the project proponent, from the amount of CO_2 stored.

A third most detailed option would be to add also the emissions due to transport by road tankers or ships.

Key questions for the technical workshop:

The pros and cons of the three approaches for quantification of GHG savings from CCS projects are summarised in Table 2.1. and will serve as a basis for the discussions at the technical workshop.

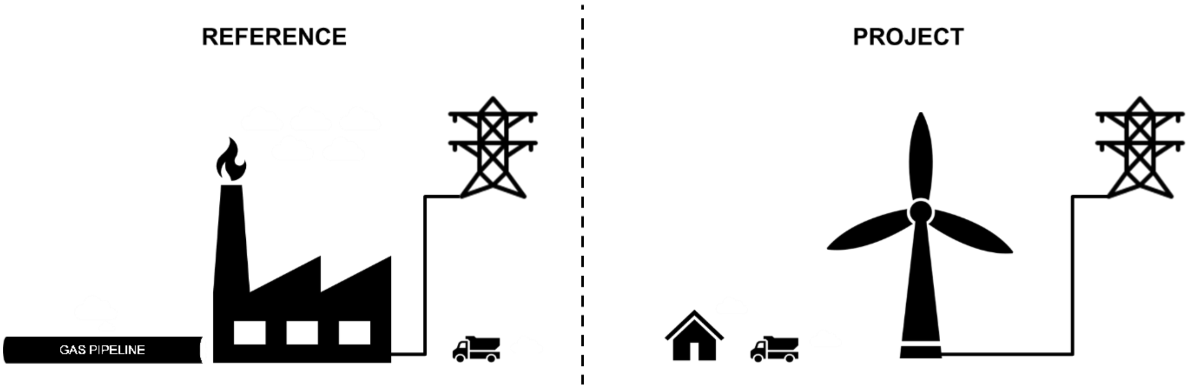
Table 2.1 Pros and cons of potential approaches for quantification of GHG savings for CCS projects

Potential approaches for quantification	Pros	Cons
GHG savings equals to the CO2 stored Knowledge-sharing requirements for the other emissions *[Approach 1: NER300]*	• Low MRV requirements (CO_2 stored, fugitive and venting emissions, CO_2 transfers)	• Does not reflect the real GHG emissions avoided by the project • Expected savings are masked, as some significant sources for the project might end up being omitted, leading to unfair comparison with other IF projects
GHG savings equals to the CO_2 stored, minus emissions for CO_2 capture, transport by pipeline and injection *[Approach 2: sensible simplifications]*	• Aligned to ETS requirements (i.e. inclusion of other stationary combustion at installations including booster stations) • Emissions are sufficiently accurate, as most relevant emissions are quantified	• More resource consuming for both quantification and monitoring • CO2 transport by road or sea are not counted, although they are typically higher than by pipeline. • Not compatible with RED2 CCS method
GHG savings equals to the CO_2 stored, minus emissions for CO_2 capture, transport by pipeline, road tanker or ship and injection *[Approach 3: detailed]*	• Most accurate and fair way to compare the impacts of two different scenarios • Exposes potentially hidden impacts from transporting CO2 by road tankers or ships, which can inform future legislation • Compatible with REDII and the method for other IF projects	• Time and resource consuming for both quantification and monitoring, e.g. in particular for transportation (e.g. vessels) • No available MRV guidance for road and water transport of CO2

2.3 Renewable Energy

GHG savings from **renewable energy (RE) projects** are the difference between the emissions from the renewable project activity, and the emissions that would occur in the absence of the project for the generation of the same amount of energy using the conventional technology, as illustrated in Figure 2.4.

Figure 2.4 Illustrative representation of emissions sources in a conventional power plant using fossil fuels (Reference) and in a wind power plant (Project)



Such savings can be quantified through the generic Equation below:

$$GHG_{Savings} = \sum_{y=1}^{n} (GHG_{Reference,y} - GHG_{Project,y})$$

Where:

$GHG_{Savings}$ = GHG emissions avoided due to energy generation from renewable energy sources during period n, in tCO_2e.

$GHG_{Reference,y}$ = Annual GHG emissions for the generation of the same energy using a reference technology, in tCO_2e per year.

$GHG_{Project,y}$ = Annual GHG emissions from the renewable energy production, in tCO_2e.

n = last year of operation of the project[16].

The complexity of the calculation of GHG reference and project will vary depending on the output and the renewable energy source (RES) used for the generation. For instance, if the output is grid-connected electricity, then the reference scenario would be equal to the fossil fuel emissions displaced from the grid, whereas in the case of heat this would most likely be provided by natural gas or heating oil. In the case of biofuels, the reference would be the GHG emissions of the displaced fossil fuels for transport. Note that the reference technology for the purpose of the calculation of emissions might not necessarily align to those in the relevant cost methodology.

In terms of the project, then sources will depend on the technology and supporting infrastructure for the operation of the plant. Normally, emissions from wind, solar and ocean energy generation are negligible and, therefore, could be disregarded from the equation for simplification. However, the same is not true for other renewables, such as geothermal, biofuels, biomass carriers, where emissions could include fuel combustion

[16] or for first 3 to 10 years of operation depending on the cut-off date of the comparison for the IF applications.

in the plant and in on-site machinery, imported electricity consumed in the plant, fugitive losses in steam (geothermal), and other direct emission sources.

2.3.2 Approaches for estimating GHG savings

The first option for the IF would be to compare projects not by the GHG emissions they save over the project's lifetime but by the amount of renewable energy they are expected to generate. Besides being a relatively straightforward alternative for applicants, it would entail low MRV requirements. To compensate this simplistic approach, the knowledge-sharing requirements should impose revealing of all the emissions due to the renewable energy production.

A second and still simple approach, is assuming that the amount of renewable energy generated displaces the energy produced at the conventional plant, and convert these quantities into emissions using the appropriate emission factors.

Whilst this approach makes it easy for proponents to quantify and to monitor GHG savings it may jeopardise comparison as the oversimplification assumes that, in most cases, the project will generate no emissions.

For biofuel projects, GHG savings would not occur at the production facility, but during use. Therefore, comparison should occur between the combustion of the biofuel being produced and the fuel it most likely replaces for the same use. Using biodiesel production as an example, it could be assumed that it would be replacing diesel. Savings would occur when you burn a large volume of biodiesel instead of a pure diesel, in either vehicles or for manufacturing due to the biogenic nature of the CO_2 being release in the project scenario as opposed to the CO_2 from fossil origin being released in the reference scenario.

For an accurate depiction of real-life emission savings of a RES project, boundaries of the calculations should be broadened to expose potentially hidden environmental impacts from clean technologies, such as emissions for the extraction of rare earth minerals to produce photovoltaic panels for solar projects, or a floating wind turbine that although clean might require more frequent maintenance using fossil fuelled boats. The downside of this rather detailed approach is that there is no simple way to quantify life cycle emissions, and the farther you go from the production site the more uncertain is the data.

Under a sensible simplification approach, selected emissions sources would be disregarded and default factors would be adopted to the point it does not affect the quality of results for the given purpose. Under this approach, although not all emissions sources from cradle-to-grave would be accounted for, the main emissions sources for each specific project type would be captured.

For instance, for a waste-to-energy project, off-site transportation of residues from the site where they would be originally disposed to the power generation plant should be included to prevent leakage in case residues are being transported from long distances. GHG emissions that would occur for the treatment of that waste in the absence of the project activity could also be added to the baseline emissions – whether these would be landfilled, incinerated or composted otherwise.

2.3.3 Suggested methodologies

<u>Approach 1: NER300</u>

The first option is to maintain the **NER 300 status quo**, i.e. to compare technologies and project applications based on the amount of renewable energy they are expected to generate, without converting these into emissions and without the need to establish a reference scenario. Knowledge-sharing requirements to be imposed on all emissions due to the RE project.

Approach 2: simplified

In the **simplified** approach, the annual GHG savings would match the emissions occurring in the reference scenario for the production of that amount of energy. Project emissions would be assumed to be zero in most cases, as shown in the equation below:

$$GHG_{Savings,y} = GHG_{Reference,y} - 0$$

Approach 3: sensible simplifications

Under a **sensible simplification** approach some emissions sources attributed to the project activity would be quantified in both reference and project scenarios. For instance, emissions from releases of steam related to geothermal projects, fossil fuel use in geothermal and bioenergy power plants, off-site transportation of residues and waste treatment for biomass-to-energy projects.

Table 2.2 below shows examples of methodologies and sources that could be used to estimate GHG savings for the various purposes of RES technologies.

Table 2.2 Formulas used for the calculation of Annual GHG emission avoidance of RES projects under Approach 3

Annual GHG savings from projects =	**Reference emissions**	**–**	**Project emissions**
Grid-connected electricity from solar / wind / ocean	$EG_y * EF_{grid,y,y}$	–	0
Grid-connected electricity from geothermal	$EG_y * EF_{grid,y,y}$	–	$PE_{dry\ or\ flash\ steam} + PE_{binary}$
Grid-connected electricity from biofuels	$(EG_y * EF_{grid,y,y}) + (GHG_{waste})$	–	$(EG_y * EF_f) + PE_{off\text{-}site\ transp}$
Heat generation from solar / wind / ocean	$EG_y * EF_f$	–	0
Heat generation from geothermal	$EG_y * EF_f$	–	$PE_{dry\ or\ flash\ steam} + PE_{binary}$
Heat generation from biofuels	$(EG_y * EF_f) + (GHG_{waste})$	–	$(EG_y * EF_{bio}) + PE_{off\text{-}site\ transp}$
Biofuel production	$V_b * NCV_b * EF_f$	–	$V_b * NCV_b * EF_b$
Biomass carriers' production	$(M_b * NCV_b * EF_f) + (GHG_{waste})$	–	$M_b * NCV_b * EF_b$
Biogas production	$(V_b * NCV_b * EF_f) + (GHG_{waste})$	–	$V_b * NCV_b * EF_b$

Where:

EG_y = Energy Generated by the project in year *y,* in MWh. For grid-connected electricity projects, only the energy generated and fed into the grid should be accounted for, i.e. any electricity generated for internal use shall be deducted. For the situations where the project involves retrofit/capacity added to an existing plant, only the surplus should be accounted for.

$EF_{grid,y}$ = Average grid emissions factor for year *y*, in tCO_2e/MWh.

GHG_{waste} = Emissions from waste treatment degradation or treatment e.g. composting, landfill disposal, incineration for solid waste and flaring for biogas, in tCO_2e.

EF_f = Emission factor for the supply and combustion of the reference fuel type *f* (i.e. “typical emissions” from REDII), in tCO_2e/MWh.

EF_b = Emission factor for the supply and combustion of the project biofuel type *b* in tCO_2e/MWh.

$V_{b,\,y}$ = Volume of biofuel or biogas produced in year *y,* in litres or m^3.

NCV_b = Net Calorific Value for project biofuel, biogas or biomass type b, in MWh per volume (in litres or m^3) or mass (tonne).

$M_{b,y}$ = Mass of biomass type f produced in year *y*, in tonne.

$PE_{dry\ or\ flash\ steam}$ = Project emissions from the operation of dry steam or flash steam geothermal power plants due to release of non-condensable gases in year y, in tCO_2e.

PE_{binary} = Project emissions from the operation of binary geothermal power plants due to physical leakage of non-condensable gases and working fluid in year y, in tCO_2e.

Alignment of IF and REDII.

As with REDII, savings from biofuels production under the sensible simplification approach, would be quantified by deducting emissions for the production and use of the biofuel from the emissions for the production and use of the fossil fuel *comparator* for transport or useful heat or electricity.

However, boundaries for the quantification of savings under REDII seem broader as it requires the quantification of emissions from:

- Extraction or cultivation of raw materials;
- Carbon stock changes caused by land-use change;
- Processing;
- Transport and distribution;
- Fuel in use;
- Savings from soil carbon accumulation via improved agricultural management, where applicable;
- Savings from CO_2 capture and geological storage, where applicable; and
- Savings from CO_2 capture and replacement, where applicable.

Emissions from capital goods (i.e. manufacture of machinery and equipment) are not accounted for in REDII. Emissions that can be deemed as zero under REDII, are:

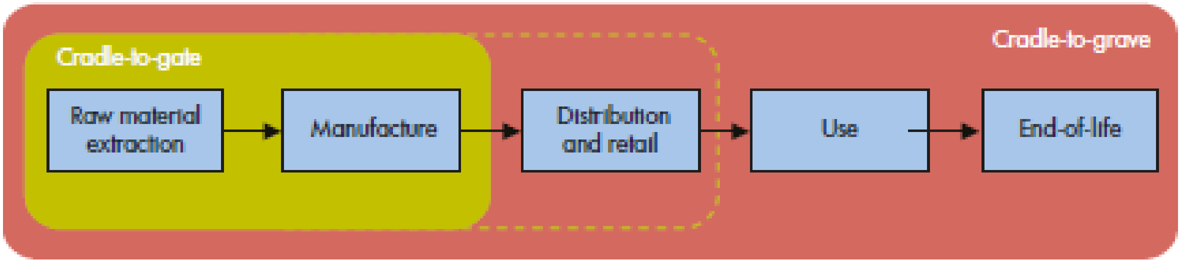
- Combustion emissions for biofuels and bioliquids.
- CO_2 combustion emissions for biomass fuels. Emissions of non-CO_2 greenhouse gases (CH_4 and N_2O) from the fuel in use shall be included
- Life-cycle GHG emissions up to the process of collection of wastes and residues, including tree tops and branches, straw, husks, cobs and nut shells, and residues from processing, including crude glycerine (glycerine that is not refined) and bagasse, irrespectively of whether they are processed to interim products before being transformed into the final product.
- Indirect land-use change emissions for biofuels, bioliquids and biomass fuels produced from selected feedstock categories.

If these sources of emissions are to be included within IF project boundaries, then alignment with REDII shall be sought.

Approach 4: detailed

Under the **detailed** approach, all the environmental inputs and outputs associated with the production of the renewable energy should be mapped – whether these occur upstream (e.g. extraction/production/transportation of raw materials and fuels), on-site or downstream (e.g. transmission and use), as illustrated in Figure 2.5.

Figure 2.5 Boundaries of life cycle inventories. Cradle-to-gate boundaries can vary according to the position of the 'gate'



Source: PAS2050.

Should this approach be selected, then this mapping exercise would have to be done for both reference and project scenario, and corresponding activity/consumption data collected in line with at least one of the internationally recognised methodologies for Products' Life Cycle Inventories, listed below.

ISO	ISO 14044:2006: Environmental management. Life cycle assessment. Requirements and guidelines
GREENHOUSE GAS PROTOCOL	Product Life Cycle Accounting and Reporting Standard
bsi.	Publicly Available Specification (PAS) 2050: Specification for the assessment of the life cycle greenhouse gas emissions of goods and services

Emissions from capital goods decommissioning of the production facility (i.e. disassembly of the machinery, equipment and building, and the recycling or disposal of the materials) will not be quantified in whatever quantification approach is selected. The inclusion of such emissions within the boundaries of the calculation would require a significant use of assumptions and extrapolations, given the limited degree of knowledge on the actual treatment of materials at the end-of-life (EoL), reducing the accuracy of the GHG savings estimates in comparison to the value that such information would eventually add.

Key questions for the technical workshop:

The pros and cons of these approaches are summarised in Table 2.3. and will serve as a basis for the discussions at the technical workshop.

Table 2.3 Pros and cons of potential approaches for quantification of GHG savings for renewables projects

Potential approaches for quantification	**Pros**	**Cons**
Amount of renewable energy produced Knowledge-sharing requirements for the emissions due to the project [*Approach 1: NER300*]	• Low MRV requirements (i.e. only energy generated needs to be monitored)	• Will likely lead to unfair comparison of RES projects and other types of IF-eligible project
RE displaces the energy (and associated emissions) produced at the conventional plant [*Approach 2: simplified*]	• Low MRV requirements (i.e. only energy generated needs to be monitored) •	• Does not reflect the GHG emission avoided by the project • Expected savings are masked, as most significant sources for the reference or project might end up being omitted, leading to unfair comparison of different RE projects
Comparison of most significant emission sources within the project boundaries, with a pre-defined reference scenario and factors *[Approach 3: sensible simplifications]*	• Emissions are sufficiently accurate, as most relevant emissions are quantified • Efforts for quantification might be reduced if assumptions and factors are pre-set and provided	• Broad variety of scenarios to be considered when developing the framework • Loss of accuracy with the use of default emission factors and actual baseline
Comparison of cradle-to-grave (or to-gate) emissions for reference and project scenarios [*Approach 4: detailed*]	• Most accurate and fair way to compare the impacts of two different scenarios • Exposes potentially hidden impacts from allegedly clean technologies	• Time and resource consuming for both quantification and monitoring • Uncertainties related to activity data used to quantify indirect emission sources

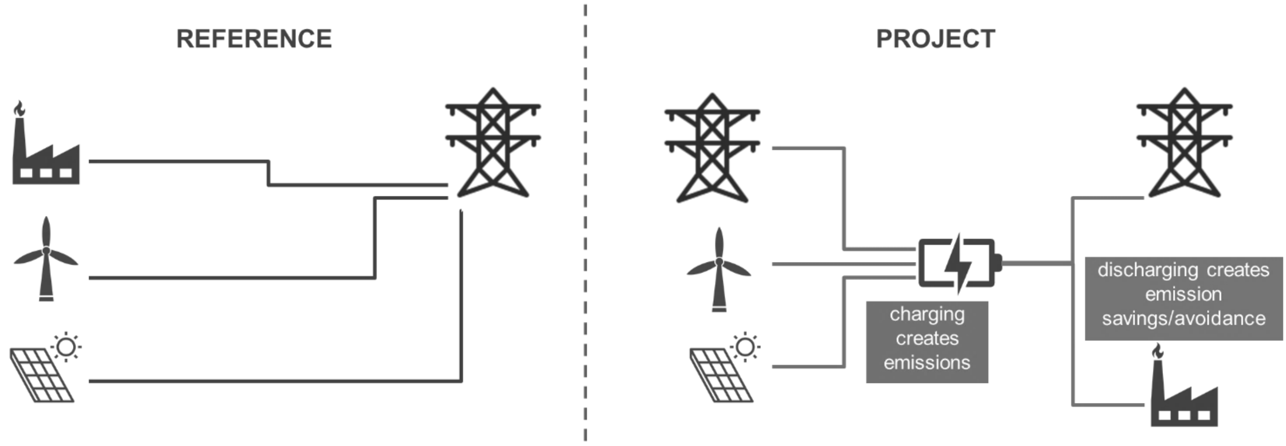
Key questions for the discussion at the technical workshop:

- Which boundaries and exclusions should be aligned to those from REDII?
- For biomass carriers' projects: If emissions from waste treatment are to be included in the reference scenario, shall we assume that waste would be composted, landfilled, incinerated or treated using the most likely treatment in the Member State? Similarly, if biogas to energy, should we assume that CH_4 would be directly released in the reference scenario or flared?
- Combustion of fossil fuel from project plant and off-site transportation (bioenergy projects) shall be included or should be assumed that such emissions would also occur in the reference plant (e.g. leakage from gas pipeline if natural gas)? Should the emissions from decommissioning of the production facility be accounted for?
- When determining the amount of Energy Generated by projects, only the amount fed into the grid should be accounted for, i.e. any electricity generated for internal use shall be deducted. For the situations where the project involves retrofit/capacity added to an existing plant, how should the surplus be measured?
- Emission factors and assumptions shall be aligned across all IF projects. When defining reference scenario, should the most conservative emission factors be adopted (e.g. heavy fuel oil for heating), a blend or the most likely alternative (e.g. natural gas for heating) or the real fuel being replaced from the reference scenario? If emission factors are used, shall these vary to match regional context (i.e. some Member States are still more reliant on fossil fuels than others so reference fuel would differ)?

2.4 Energy Storage

Energy storage is defined as the act of deferring an amount of the energy (electricity, heat, hydrogen, gaseous or liquid hydrocarbon) that was supplied to the moment of use, either as final energy or converted into another energy type.[17] A project applying for funding under the Innovation Fund should be classified as an energy storage project, if energy storage (in any of the forms defined above) is the major purpose or one of its major purposes. For example, this means that an electrolysis unit coupled to a hydrogen storage is classified as an energy storage project, while the production of hydrogen for immediate use (e.g. in the chemical industry) is not. Any project (i.e. not necessarily an energy storage project) making use of fluctuations in electricity markets should in principle apply the method developed for charging/discharging of energy storage units connected to the electricity grid (three possible methodologies were presented in section 2.1).

Figure 2.6 Illustrative representation of energy storage



The savings can be quantified through the generic equation below:

$$GHG_{Savings} = \sum_{y=1}^{n} (\Delta GHG_{discharge,y} - \Delta GHG_{charge,y})$$

Where:

$GHG_{Savings}$ = GHG emissions avoided due to operation of the energy storage during the first n years of operation, in tCO_2e.

$\Delta GHG_{discharge,y}$ = Annual GHG emissions avoided due to discharging of the energy storage, in tCO_2e.

$\Delta GHG_{charge,y}$ = Additional annual GHG emissions due to charging of the energy storage, in tCO_2e.

n = number of years of the period considered.

The general framework for assessing the potential GHG emission avoidance of an energy storage project is developed along four guiding questions that need to be answered by the project proponent:

1. Which type of energy is going to be stored?
2. What are the key characteristics of the storage unit?

[17] To our knowledge, there is no definition of energy storage in any EU regulation. The definition provided here is a generalization of the definition for the electricity sector given in the SWD “Energy storage –the role of electricity”, available online at: https://ec.europa.eu/energy/sites/ener/files/documents/swd2017_61_document_travail_service_part1_v6.pdf.

3. How is the storage unit charged?
4. How is the storage unit discharged?

The options available for Questions 3 and 4 will depend on the type of energy stored. Within the method, the storage of electricity and its conversion to other energy types has a particular role because the charging and discharging of storage units connected to the electricity grid provides the option of taking into account the fluctuation of electricity prices and the related GHG emissions corresponding to the marginal generating plant. The framework therefore allows to select whether the storage will be connected to the grid or not during charging and/or discharging. If this is not the case, individual information about the sources for charging and discharging needs to be provided and verified. There are various approaches to calculate emission factors of electricity from the grid, which are presented in the Annex 1.

For energy types other than electricity, a default case will be provided that is aligned to the methodology for assessing GHG emission avoidance for other project types. In certain cases, there will be also the option to select the provision of individual information if sufficient evidence can be provided.

2.4.2 Approaches for estimating GHG savings

Three different methodologies for calculating greenhouse gas emission reductions associated with the storage of energy were compared. Since the calculation of greenhouse gas emissions for non-electricity-based energy is relatively simple the three approaches differ only with regard to the calculation of emissions from the electricity sector.

1. An estimation based on hourly emission factors from the electricity grid sector during the charging and discharging hours of the storage.
2. A simplified methodology that takes only into account the amount of energy stored. This means emission avoidance during discharging is estimated based on an average annual emission factor of the electricity grid and emissions due to charging are omitted. A further simplified variant of this methodology is to consider only the stored energy without translating into GHG emission avoidance at all. Knowledge-sharing requirements will be added in this case to reveal the real GHG emissions avoided by the project during its operation.
3. A methodology that is in the middle of the two other approaches in terms of level of detail. In this methodology, the emissions due to charging are set to zero in hours, where the storage is used for grid purposes (e.g. curtailment) or charged with renewable electricity proven to be additional, while in all other hours a grid-based average annual emission factor is used.

In Methodology 1, the emission factors of electricity generation in the charging hours of the storage are considered; these are multiplied by the amount of electricity charged in the respective hours to estimate the additional emissions caused by charging the storage. This is compared with the emissions avoided by discharging the storage. If the discharge takes place in the industrial sector (e.g. via the use of Power-to-heat, Power-to-liquid, Power-to-H_2 technologies) or the stored energy is used as a fuel (e.g. Power-to-liquid), then the relevant ETS benchmarks will be used to estimate the avoided emissions. For example, if heat was previously generated by fossil fuels in an industrial plant and is now generated by the storage, the heat benchmark from the EU ETS can be used to calculate which amount of emissions was caused by the combustion of fossil fuels before the storage was used. These are then the greenhouse gas savings that result from discharging the storage. If the storage is discharged to the grid, the emissions are also calculated on the basis of grid-based emission factors in the discharging hours multiplied by the amount of electricity discharged. This approach therefore requires hourly grid-based emission factors of the electricity sector. Furthermore, it is important at which hours charging and discharging takes place. The approach therefore requires a large amount of data and assumptions (e.g. assumptions about the hours at which the storage is charged and discharged). The monitoring, reporting and verification (MRV) of GHG emission avoidance would also become rather complex because, for example, hourly generation data for all technologies would have to be evaluated, which would require substantial efforts. Furthermore, it is rather likely that actual charging hours differ significantly from the assumed charging hours in the ex-ante calculation, resulting in uncertainty about the performance and therefore disbursement.

Approach 2 is based only on the amount of energy stored. In this case, an average emission factor of electricity generation in one year is calculated. This is multiplied by the amount of energy stored, which results in the emissions avoided. If the discharge does not take place in the grid, but in the industrial sector, for example for heat generation, the emissions avoided are calculated as in Methodology 1. This approach represents a very simple approach, which makes only minimal demands on MRV because one would only need an annual average emission factor of the grid. However, it is immediately clear that in such a case the emission reduction will always be positive, even if the charging of the storage causes higher emissions than its discharge. In this case, each unit of energy stored would lead to additional emissions reductions. This in turn provides an incentive for applicants to keep the storage operating for as long as possible, which in most cases would lead to an increase in greenhouse gas emissions, in contradiction with the goals of the Innovation Fund. The further simplified variant of this methodology is to consider only the stored energy without translating into GHG emission avoidance at all. This variant has the advantage that no emission factors are required for calculation and therefore there would be no uncertainty about future developments, which would make MRV even easier. However, the described potential for misincentives apply for this variant as well. In both cases, knowledge-sharing requirements will be imposed to reveal the real GHG emissions avoided and help in this way advance the technology development.

Approach 3 represents a more sensible simplification than approach 2. In this case, the number of charging hours is required as well as the number of hours in which the storage is used for grid purposes (e.g. to avoid curtailment or to provide system services based on the energy balancing markets) or charged by renewable electricity with proven additionality (see Section 2.1.2.2 for the requirements for additionality). It is assumed that in the latter hours there are no additional emissions during charging. If the number of charging hours is larger than the number of hours with curtailment, these additional hours are calculated with the emission factor used in Methodology 2. Emissions avoided during discharge are calculated for all sectors in the same way as in Methodology 2. In particular, it is assumed that no discharging takes place during hours of curtailment. This can be justified by the fact that electricity prices are always low during curtailment hours and that, from an economic point of view, discharging would be disadvantageous. Compared to Methodology 1, this methodology results in lower effort and MRV is also simpler (only emission factor of the grid as well as suitable evidence for grid-based usage, e.g. operation times on balancing markets, and/or information about additionality of renewable electricity (Section 2.1.2.2), while the approach is more accurate than approach 2. However, the methodology has weaknesses compared to approach 1 in case that the storage is only used based on economic profits, and it is more likely that the actual use of storage deviates from the ex-ante estimation than in approach 2.

2.4.3 Suggested methodologies

Preliminary tests of the methodology with project examples have shown that the use of storage technologies does not necessarily lead to a reduction in GHG emissions. In particular, this often applies to electricity storage systems used to maximise profits based on arbitrage on electricity markets. This is mainly due to the fact that the greenhouse gas-intensive production of lignite-fired power plants is cheaper than the less GHG-intensive production of electricity by gas even for relatively high CO_2 prices. The same also applies to the other cases in which electricity is used to charge the storage. If an electrolyser is charged with electricity from coal-fired or gas-fired power plants, it hardly leads to greenhouse gas reductions compared to conventional hydrogen production processes. Storage technologies can therefore in most cases only lead to greenhouse gas reductions, if they are charged only or at least with a large share of renewable energies. Should a storage unit be charged with renewable electricity, the question arises whether the electricity with which the storage unit is charged would not be generated without the storage unit, or whether the electricity would otherwise be fed into the grid. In the second case, the storage unit does not lead to greenhouse gas reductions, since this renewable electricity is not available to the grid and must therefore be generated by fossil power plants. Thus, effective greenhouse gas emission reductions through storage technologies will mainly be achieved if the storage units prevent curtailment of renewables or if the renewable electricity used can be proven to be additional (see Section 2.1.2.2). How much curtailment will happen in the future, however, depends heavily on the expansion of the European electricity grid.

The example presented in the following is a plant for the production and storage of hydrogen via electrolysis.[18] The electricity needed for electrolysis is mainly provided by renewable energy. This is guaranteed because the plant is located directly next to a grid connection point of an offshore wind park. The hydrogen can be stored for a longer period of time and is sold to industrial companies that use it for various purposes. As the use of hydrogen is not linked to a specific industry or product, the hydrogen benchmark from the EU ETS is chosen as the reference. In addition to hydrogen, the heat from the electrolysis is fed into a district heating network. Therefore, the example is not only about power-to-hydrogen, but also about power-to-heat. For this reason, the heat benchmark from the EU ETS is also used for the heat generated. The electrolysis runs with electricity from wind, which is GHG-neutral, but this wind electricity is withheld from the grid. This means that the grid electricity has higher emissions, as if the electricity generated in the wind park concerned would be fed into the grid. As long as there is no curtailment of the renewable electricity, the charging of the storage thus cannot be regarded as GHG-neutral and the grid-based emission factors are used to calculate the charging emissions. However, if the electricity from the wind park can be proven to be additional, the total electricity consumption of the electrolyser would have to be considered GHG-neutral.

The example presented is calculated for two possible locations: Germany, where the plant is planned to be located, and Ireland as a location with rather different conditions. In the 2030 scenarios used, the regional conditions are as follows:

- Germany has little curtailment due to its connectivity with other countries, which means that charging the storage tends to be related to higher emissions and therefore the use of storage leads to lower or even negative greenhouse gas reductions.

[18] based on the getH2 project

- Ireland, on the other hand, has significantly more curtailment due to its island geography, which in turn means that storage units are often charged with surpluses from renewable energies.

This means that charging the storage facility in Ireland is associated with fewer emissions than in Germany, which also means that greenhouse gas reductions through storage are higher in Ireland than in Germany. With regard to the expected number of hours in which the plant is in operation, two possibilities were calculated. On the one hand, it was assumed that the plant will run 24/7 and on the other hand, a sales price of hydrogen was assumed, which in turn determines the maximum electricity price at which it is economically profitable to operate the plant. The calculation was based on scenario projections mainly in line with the current EU 2030 targets. It was carried out for all methodologies presented in Section 2.2.

<u>Approach 1 detailed:</u>

The calculation formula of approach 1 for the example project is the following:

$$ConvEff * StorEff * EC_y * EF_{ETS\ H2} - \sum_t \left((EC_{t,y} - EC_{t,y,zero}) * \mathrm{EF}_{t,y} \right)$$

Where:

ConvEff = conversion efficiency

StorEff = storage efficiency

ECy = total energy charged in year y

$EF_{ETS\ /H2}$ = emission factor based on ETS benchmarks for hydrogen production

$EC_{t,y}$ = energy charged in hour t in the year y

$EC_{t,y,zero}$ = energy charged for grid purposes or from additional renewable electricity in hour t in year y

$EF_{t,y}$ = hourly marginal emissions of electricity generation

The first term of the equation shows the emissions avoided by discharging the storage, or in this case, by using the hydrogen from the electrolyser instead of conventionally produced hydrogen. Conversion losses and also losses that occur during storage (volatility of hydrogen) are taken into account. Multiplied by the charged energy, you get the energy that is available as hydrogen. This multiplied by the EU ETS emission factor for hydrogen gives the emissions avoided by using this hydrogen. Note: The EU ETS hydrogen benchmark is given in tonnes and not in energy, so the energy available as hydrogen must be calculated in tonnes (39.41 MWh/t) before multiplying it with the ETS benchmark.

The second term describes the additional emissions caused by charging the storage. The charged energy is taken for every hour in which the storage is charged. In hours in which the storage is charged from additional renewable electricity, these hours are considered with zero emissions and are therefore not considered in the calculation (subtracted). The hours during which the storage is not charged with greenhouse gas neutral energy are multiplied with the emission factor of the specific charging hours. The sum over all hours then forms the additional emissions caused by charging the storage.

The results of the 24/7 operation of the plant for Germany show a small increase in greenhouse gas emissions, whereas for Ireland a bigger decrease in emissions is expected. Assuming that the electrolysis unit is used depending on the electricity price and an average market price for hydrogen, the production only becomes economically viable below a certain electricity price. As lower electricity prices are often linked to a higher share of renewable energy curtailment, the reduced duration in Ireland leads to even higher GHG savings because in this case it is ensured that the storage is mainly not charged at times of high emissions in the electricity sector. For Germany, on the other hand, there is an increase in emissions in this case due to the low number of hours with curtailment and the fact that at times of low electricity prices in Germany coal-fired power plants often represent the marginal technology. Whereas in times of higher electricity prices gas or biomass power plants tend to represent the marginal technology.

Approach 2 simplified:

The calculation formula of approach 2 for the example project is the following:

$$ConvEff * StorEff * EC_y * EF_{ETS\ H2}$$

As approach 2 only considers the emissions avoided due to the discharge of the storage, there is no difference in the example between the first term in approach 1 and the whole formula in approach 2. For power-to-power storage, on the other hand, there would be a difference, since in this case approach 1 would again be based on hourly marginal emissions, analogous to the charging of the storage in approach 1, whereas approach 2 would be based on a grid-based average emission factor over one year.

For the approach 2, the use of the plant leads in all cases to a decrease in emissions. This is because no additional emissions are covered from the charging process. Due to this fact, approach 2 always leads to GHG emission reductions and these are always significantly higher than the reductions in the other two methodologies. This is in strong contradiction to the findings from the more detailed approach 1.

Approach 3 sensible simplifications:

The calculation formula of approach 3 for the example project is the following:

$$ConvEff * StorEff * EC_y * EF_{ETS\ H2} - (EC_y - EC_{y,zero}) * MEF_{r,y}$$

Where:

EC_y = energy charged in year y

$EC_{y,zero}$ = energy charged for grid purposes or from additional renewable electricity in year y

$MEF_{r,y}$ = mean or marginal emission factor of electricity in region r in year y

Approach 3 calculates the emissions avoided for the present example in the same way as in the two previous methodologies. In the power-to-power case the reductions would be calculated in the way sketched under approach 2.

The additional emissions from the charging of the storage are calculated in approach 3 as follows. The total number of hours the storage is charged is considered, subtracting the number of hours the storage was running for grid purposes or from additional renewable electricity. The number of hours that the storage was not operated for grid purposes or from additional renewable electricity is then multiplied by an emission factor.

The results are very close to the results of approach 1 in all the calculated cases. Only in the case of an economically optimised deployment in Germany there is a moderate deviation, although the sign of the result is the same here too.

Table 2.4 shows an overview of the results of the three different methodologies for the four cases. The number of the arrow symbols represents how strongly emissions are decreasing (↓) or increasing (↑).

Table 2.4 Comparison of the three methodologies with selected examples

Country	Operating time	Methodology 1	Methodology 2	Methodology 3
Germany	24/7	↑	↓↓↓	↑
	economical	↑	↓	0
Ireland	24/7	↓	↓↓↓	↓
	economical	↓↓	↓↓↓	↓↓

To keep the example simple and instructive, the waste heat was not taken into account in the example calculations, but could be included easily as an additional positive contribution to GHG emission avoidance. Table A1.1 in the Annex 3 shows the formulas to be used to calculate GHG savings for all the various kinds of energy storage technologies for approach 3.

Key questions for the technical workshop:

Table 2.5 summarises the advantages and disadvantages of the three approaches and will serve as a basis for discussions at the technical workshop.

Table 2.5 Pros and cons of potential approaches for quantification of GHG savings for energy storage projects

Potential approaches for quantification	Pros	Cons
Comparison of reference and project scenarios **based on an hourly charging and discharging profile** *[Approach 1: detailed]*	• Most accurate way to compare the impacts of two different scenarios • Exposes potentially hidden impacts from economic optimisation	• Complex MRV requirements (hourly load profiles and emission factors) • Highest uncertainties in ex-ante assessment
Comparison **based on annual amount of energy stored only and average annual emissions factor** + knowledge-sharing requirements during operation *[Approach 2: simplified]*	• Low MRV requirements (i.e. only the amount of energy stored needs to be monitored for the purposes of disbursement) • No risk related to uncertainty over achieved performance and therefore disbursements	• Weak link to real GHG emission avoidance • Incentive to store energy also at times when not useful
Comparison **based on annual energy stored, average annual emissions factor and curtailment**	• Stronger link to real GHG emission avoidance than simplified approach • Moderate MRV	• Higher uncertainties in ex-ante assessment than simplified approach • No full accounting of

Potential approaches for quantification	Pros	Cons
[Approach 3: sensible simplifications]	requirements (amounts of energy stored and times of usage for different purposes)	hidden impacts of economic optimisation

Key questions for the technical workshop:

- *An energy storage project can be responsible for the amount of energy stored and timing of (dis-)charging, but the "reference emissions" are outside of control. The ex-ante targeted reductions might not be achieved if the emission factors applied to discharging decrease more than assumed in the ex-ante calculation or the emission factors applied to charging decrease less than expected. How can energy storage projects actually prove avoided emissions? What evidence should they provide to prove they have operated the storage unit as planned?*

  First of all, the required calculation procedures may foster the robustness of estimates, e.g. by using EU averages instead of local emission factors (see also the last question below). In addition, the storage operator could still provide evidence that the storage was used in the way foreseen during the application procedure. One possible approach here is that for the times when the storage unit is charged and discharged on balancing markets or without connection to the grid the GHG emission avoidance could be marked as achieved, while for the times that the storage is charged and discharged based on economic optimisation on wholesale markets, the risk would remain with the operator and GHG emissions avoidance would be estimated based on empirical data on the emission factors, e.g. from ENTSO-E.

- *Energy storage solutions are enablers to integrate clean energy. If this is not taken into account, energy storage projects may perform poor with respect to GHG emission avoidance calculations. How to deal with this?*

  For certain energy storage projects, only the sum of outputs (e.g. electricity and heat) may yield a GHG emission avoidance. While the methodology will become a bit more complex, it is relatively straightforward to include such additional benefits. However, as many energy storage projects make use of very specific local conditions, e.g. grid congestion, it will likely not be possible to capture all the relevant cases in a general framework. Nevertheless, the same criteria will apply to all energy storage projects. Moreover, the comparison with other types of projects is planned to reflect the different types by using appropriate weighting factors.

- *While the GHG emission avoidance criterion considers the individual projects, scalability to the EU level is one of the further criteria. Which emission factors for electricity generation should be applied: national ones, EU-wide averages or a mixture?*

  Scalability is a criterion of the Innovation Fund separate to GHG emission avoidance. So the performance on EU scale will be judged separately. For the GHG emission avoidance criterion, there are important arguments both for national and EU-wide emission factors. A regional component may reflect the regional RES generation and its potential curtailment on the level of Member States, while an EU-wide average reflects that the marginal power plant is often located in another EU Member State given the high integration of EU electricity markets. The latter will also be more robust to uncertainties about the national energy pathways. Further clarification in the workshop will be required.

2.5 Production facilities of key components for innovative renewable energy technologies and energy storage

GHG emissions savings from projects that involve the production of innovative components of machinery for renewable energy and energy storage technologies will occur at the energy generated or stored by the technology being manufactured, and not at the manufacturing of the technology.

2.5.1 Suggested methodologies

Manufacturers of innovative components of RES technologies projects would estimate GHG savings using the same approach that *operators* of the corresponding RES technology project would use, as described in section 2.3.3. Whereas producers of innovative components of energy storage technologies should use the approach described in section 2.4.3.

Under this assumption, a manufacturer of an innovative wind turbine, for instance, would estimate the energy that the new turbine(s) will generate per year and quantify annual GHG savings using the equation corresponding to this technology in Table 2.3 and expected output. An extract of this table is shown below.

Grid-connected electricity from solar / wind / ocean	$EG_y * EF_{grid,y\ ,y}$	–	*0*

Where:

EG_y = expected total energy generated by the innovative technology and fed into the grid in year *y,* in MWh.

$EF_{grid,y}$ = Average grid emissions factor for year *y*, in tCO_2e/MWh.

The expected total energy generated (EG_y) by the innovative technology shall be calculated as follows:

$$EG_y = EG_{unit} * Q_y$$

Where:

EG_{unit} = expected energy generated/stored by one unit/component of the innovative technology, in MWh/unit.

Q_y = quantity of components of the innovative technology produced per year, in units.

Considering that savings will occur downstream (i.e. after a product or service leaves the company's control), project proponents might have challenges to monitor and evidence the delivery of the energy generated by their product.

Key questions for discussion at the technical workshop:

- The GHG emission avoidance will depend on where and how the RES or energy storage components are used. How to deal with the uncertainty about securing the delivery of the planned components to the market? How could project proponents monitor energy generated / stored in this case? Should we require sales contracts for the produced units?
- Shall we use national grid GHG intensity to estimate the emissions saved depending on where the RE or storage units would be installed? Or can we use a more simple approach estimating the GHG emissions avoided based on the EU average GHG intensity?
- What other parameters should be monitored?
- How to deal with units produced for non-EU countries? Shall IF be restricted to those components that are produced and which will deliver to EU?
- How to avoid double claiming of emission savings, e.g. if the buyer of the units also applies for IF funding?

3 Next Steps

3.1 Confirmation of key issues and assumptions

In addition to the specific questions presented throughout this document where stakeholders views are welcome, this Section brings other broader issues, assumptions and potential simplifications that will be discussed and developed at the Technical Workshop.

The agreed simplifications will form the basis for defining the methodology for estimating GHG emission avoidance. In support of that, the team will propose options to simplify certain steps of the equations, highlighting the implications of such decisions.

3.1.1 Timescale of projects

It has been proposed that the GHG emission savings for the projects be evaluated at two times

- 2030, deemed to be the typical date at which projects in the first call will be in operation and for which year the EU has clear targets or a more sophisticated calculation requiring yearly forecast based on yearly baseline emissions (e.g. for the period 2022 (earliest possible date of entry in operation) to 2037 (latest possible date of entry into operation))
- 2050, to evaluate the contribution of projects to the overarching EU ambition of climate neutrality in 2050, and to be considered in degree of innovation criterion

Points to discuss:

- Should we use one year for the reference emissions (2030) or should we provide year on year forecasts? Can we use the former for industry, CCS and RES projects while using the more detailed forecast for energy storage projects?
- Is there a danger of some projects using electricity actually increasing emissions if operated before 2030?

3.1.2 Grid electricity emissions forecasting

Annual GHG savings from grid-connected electricity renewable projects are expected to reduce over time, given the anticipated uptake of renewable energy in Europe due to national RE targets. This will have implications on both forecasting of project savings and reference scenario emissions and could be accounted for in the quantification framework and modelling.

For example, if we assume EU electricity will be completely “decarbonised” in 2050, there is no emission benefit from electricity storage. However, in that case the decarbonisation will not happen. So arguably, the grid electricity emissions during discharging by electricity storage installations, even in 2050, should be the emissions from a sort of power station that would have to exist if there is no storage: probably burning natural gas.

3.1.3 Optimal use of hydropower resources

There is a risk of perverse incentives to use hydro resources for power-to-fuels plants, when they would save an order of magnitude more GHG by being used to stabilize the EU grid to allow more incorporation of wind and PV electricity.

A pragmatic solution is proposed in the present draft: to use the average of two values: first, the time-averaged emissions for consumption of electricity at the site of the plant, and second, the EU-average emissions for consumption of grid-electricity.

Another possibility would be to allow hydro-power stations to compete with other proposals for demand management/electricity storage solutions, by building extra generating capacity so that electricity from the same water resources can be released over shorter periods, when there is not enough solar and wind (together with long-distance transmission infrastructure to deliver it where it is needed).

3.1.4 Simplified method for application in first phase

How should the requirements for project applicants differ for the first and second phase of application with the views of reducing burden at the first phase to encourage applications? Specifically, which simplifications to the quantification could be proposed for the first round (e.g. annual savings only and use of default EF), and which additional requirements should be demanded at the second phase (e.g. total GHG savings for the first 3 to 10 years, taking into consideration the expected penetration of RES)?

3.2 Preparation of draft guidance documents

Having agreed on the simplified and fully-fledged methodology, boundaries, and confirmation of which parameters of the methodology shall be pre-defined and non-adaptable, which shall be pre-defined but adaptable and which shall be set by the project proponent, the guidance for the project proponent for both the first stage proposal and the full stage proposal will be drafted.

We propose the methodologies to be presented in an objective and succinct document, aligned to the Monitoring and Reporting Regulation (MRR) templates and on the widely used templates from the UNFCCC to provide guidance on the Kyoto-Compliant GHG reduction projects, under the Clean Development Mechanism and Joint Implementation.

This structure should include at minimum the following sections:

- Scope, e.g. "*This methodology applies to projects that involve generation of grid-connected electricity, heat or steam using one or a combination of the below technologies*"
- Applicability
- Boundaries, i.e. which emissions sources and GHGs are relevant, and which could be omitted
- Formula for the GHG savings / avoidance calculation
- Formula for the Reference emissions calculation
- Formula for the Project emissions calculation
- Tables with data and parameters not monitored (i.e. national or default emissions factors that will be provided)
- Tables with data and parameters to be monitored (i.e. this to inform monitoring plan)

Annex 1 Overview of potential approaches to the greenhouse gas emission intensity of electricity taken from and/or fed into the grid

For a meaningful estimate of the GHG emission avoidance of IF projects that use electricity from the electricity grid (industry, energy storage) and/or produce electricity that is fed into the grid (renewable energy, energy storage), it will be necessary to assign an appropriate GHG emission intensity to the electricity used/replaced. The specification needs to reflect on both the spatial and the temporal dimension of the electricity usage/production, i.e. where and when the electricity will be used/produced. Both the spatial and the temporal dimension of the GHG emission intensity of electricity will be discussed in the technical workshop.

With respect to the **temporal** dimension of the electricity usage/production, several cases for the use and production need to be distinguished.

1. **Continuous use/production of electricity**: The estimated GHG emission avoidance will not depend of the hourly change of the electricity mix. Therefore, the GHG emission intensity of the electricity used/replaced may be averaged over the period of consideration, e.g. one year In this case it is not necessary to consider the marginal emissions for incremental electricity supply: the simple generating mix can be used to determine emissions[19].

2. **Stochastic intermittent production/use of grid electricity**: There is a stochastic dependency on the electricity mix over time. Due to the stochastic nature and the fact that the project proponent cannot influence the electricity replaced, the GHG emission intensity of the electricity used/replaced may again be averaged over the period of consideration.

3. **Additional renewable electricity production from wind or solar.**
   In this case there is likely to be a correlation between the times the electricity is fed in and the GHG emission intensity of the grid, because other wind and solar installations will likely be producing at the same time. Furthermore, the renewable electricity from the project is additional to national targets, so the there is no reason to suppose that the emissions savings will reflect the average grid mix. Rather, they will reflect the average emissions intensity of the power stations that will be switched off to allow the grid to absorb the extra renewable electricity. Modelling would probably be needed to estimate this.

4. **Market-dependent use of electricity from the grid:** In this case, the operation of the IF project will influence the GHG emission avoidance achieved by the project. An appropriate GHG emission intensity to derive the resulting avoidance needs to be identified. Rationally, it should be the marginal electricity emissions averaged over the time that the electricity is used. Given the rules that determine when the electricity will be used in a project, one could calculate the result for the current or historical grid supply in EU regions. However, to foresee the future result would require extrapolation or modelling.

[19] As the "Clean Energy for All Europeans" package specifies targets for renewable energy and energy efficiency in terms of percentages, one could assume that the extra electricity supply will have similar average emissions intensity to the overall grid mix. However, this ignores the intrinsic limit on water resources for hydropower, as discussed later in this annex.

In any case, to estimate and verify the avoidance, information on the planned usage may be required during the proposal stage and monitoring of the usage may be required during the operation.

5. **Market-dependent feeding of electricity into the grid:** In this case, the operation of the IF project will again influence the GHG emission avoidance achieved by the project, with the same consequences as for Case 4. However, the appropriate GHG emission intensity are likely to differ from Case 4., as the timing of usage and of production of electricity are different.

For reasons of consistency, the temporal approach applied to GHG emission intensities should be the same across all types of projects (industry, renewable energy, energy storage), as long as they fall under the same of the five cases.

With respect to the **spatial** dimension of the electricity use, the following options are most meaningful in view of the necessary precision and the requirements for measurement, reporting and verification:

1. **GHG intensity of the electricity consumed in the country of the plant**
2. **GHG intensity of the consumed electricity averaged for all EU (see A2.3)**
3. **(Weighted) Average of 1. and 2.**

All three approaches have certain advantages and disadvantages:

- **Approach 1** takes into account that there continues to be a disparity in the regional electricity mixes, while it does not reflect that there is an increasing exchange of electricity between Member States. It may lead to a strong allocation of IF projects using electricity in countries with lowest GHG emission intensity of electricity. While this is useful for the project's GHG emission avoidance, it may hinder the decarbonisation of the EU electricity mix[20]. Moreover, the required projection of the electricity mix for 2030 is more uncertain for a single Member State than for the EU as a whole.
- **Approach 2** is more robust with respect to the required projection of the electricity mix. It also reflect the increasing inter-connectedness of the EU electricity markets. However, it does not take into account the local grid limitations. It may therefore lead to placing IF projects using electricity in countries where the real GHG emission intensity of electricity will be relatively high compared to other Member States, so that some projects might not save GHG emissions at all.
- **Approach 3**: the weighted average of both Approach 1 and 2. This provides an incentive to avoid siting plants in countries with high grid emissions, but may also avoid placing projects solely in Member States with very low GHG intensity grids. However, the disadvantages of Approach 1 and 2 will still apply to Approach 3, at least to a limited extent depending on the weighting factor.

For reasons of consistency, the spatial approach applied to GHG emission intensities should also be the same across all types of projects (industry, renewable energy, energy storage). The advantages and disadvantages of the various spatial approaches are summarized in the following table.

[20] Hydropower from dams offers the most efficient and cost-effective way to stabilize the future electricity grid against increasing contributions from fluctuating wind and solar electricity. If there is sufficient generating capacity at the dam, electricity from the same water resources can be released over shorter periods, when solar and wind are in short supply. Models of future grid decarbonisation assume that European hydro capacity will be available for this, but diverting it to energetically inefficient uses like power-to-fuel will make it more difficult for the grid to cope with sufficient renewable electricity to reach the targets.

Table 3.1 Pros and cons of potential spatial approaches to the GHG emission intensities of grid-based electricity

Potential approaches	Pros	Cons
1. GHG intensity of the electricity consumed in the country of the plant	• reflects local electricity grid constraints	• may lead to a strong allocation of IF projects using electricity in countries with lowest GHG emission intensity • could impede the decarbonisation of the EU grid. • projection of GHG emission intensity is sensitive to uncertainty of future Member States pathways
2. GHG intensity of the electricity averaged for all EU	• reflects the increasing inter-connectedness of EU electricity markets • projection of GHG emission intensity is more robust with respect to uncertainty of future MS pathways	• disregards local electricity grid constraints • may result in placing IF projects using electricity in countries where real GHG emission intensity of electricity will be high, so that some might not save emissions.
3. The (weighted) average of 1. and 2.	• Roughly reflects the increasing inter-connectedness of EU electricity markets and local grid constraints	• Cons of 1. and 2. can both apply but to a more limited extent

Annex 2 Low-carbon projects in industry

A2.1 Relation with REDII

The revised Renewable Energy Directive (REDII) includes two categories of novel transport fuels, named

a. Renewable liquid and gaseous transport fuels of non-biological origin (RFNBOs);

b. Recycled Carbon Fuels (RCFs).

The Commission is developing a methodology to calculate emissions savings under REDII, and it is foreseen that this should be a development of the principles established under FQD.

The FQD, REDII and the Innovation Fund have in common that they need to account for Carbon Capture and Utilization (CCU), as well as for the use of feedstocks that are by-products, wastes or intermediate products of existing industrial processes. Although REDII inherits from REDI some rules for calculating emissions from biofuels, these fail to deal adequately with these new GHG accounting challenges.

It is intended that the methodology for calculating emissions under the IF should share the principles to be used in the calculation of GHG savings from REDII. However, there are important differences between the requirements of the IF and REDII.

- REDII calculates emissions for particular transport fuels. It is fairly easy to extend the methodology to other products using CCU or similar types of feedstock, but IF needs to calculate emissions for projects, which may produce no different products, or may produce several.
- REDII needs to calculate emissions saved specifically in the transport sector, whereas savings under IF may cover many sectors.
- IF covers sectors involved in ETS, and we should try to avoid administrative burden by using ETS data and methods where possible.

These are large differences which mean it will not be possible to apply exactly the same rules to IF projects as to RFNBOs or RCFs in REDII.

A2.2 Global Warming Emissions Considered

The greenhouses gases that must be taken into account in emissions calculations, and their carbon dioxide equivalents (Global Warming Potentials), shall be the same as specified in paragraph 4 of annex V part C of REDII, which are as follows:

Table A2.1 Global Warming Potentials (100 years)

CO_2	:	1
N_2O	:	298
CH_4	:	25

However, optionally, changes in the emissions of other greenhouses gases may be considered. In this case the latest GWP approved by the IPCC shall be used for the other greenhouse gases.

A2.3 GHG Intensity of the electricity consumption in the EU and outside EU

Table A2.2 GHG Intensity of the electricity consumed at low voltage (LV; less than 1kV) and medium voltage (MV; 1-150kV) in the European Union in 2015

Member State	GHG Intensity (LV)	GHG Intensity (MV)
	[gCO_2eq/MJ]	[gCO_2eq/MJ]
Austria	86	85
Belgium	93	92
Bulgaria	177	168
Croatia	145	139
Cyprus	228	224
Czech Republic	187	183
Denmark	53	52
Estonia	235	227
Finland	34	34
France	22	22
Germany	150	148
Greece	188	182
Hungary	115	111
Ireland	158	154
Italy	119	117
Latvia	140	137
Lithuania	128	124
Luxembourg	135	135
Malta	199	193
Netherlands	165	163
Poland	253	247
Portugal	134	129
Romania	133	125
Slovakia	117	115
Slovenia	100	98
Spain	112	107
Sweden	7	6
United Kingdom	135	131
Average EU 28	114	112

The GHG intensity in Table A is the sum of the emissions of the power plants themselves, and the upstream emissions for the provision of the primary fuels, with account taken of external trade, pump storage losses, allocation to useful heat exports, and transmission losses down to medium or low voltage. The medium-voltage figure includes an assumed 1% loss within the factory gates for transforming to low voltage and distribution. The Commission shall update the table using new input data set covering all the countries concerned as it becomes available.

Table A2.3 GHG Intensity of the electricity consumed at low voltage (LV; less than 1kV) and medium voltage (MV; 1-150kV) in the European Union in 2015

	GHG Intensity (LV)	GHG Intensity (MV)
	[gCO_2eq/MJ]	[gCO_2eq/MJ]
Average EU 28	**114**	**112**

Countries outside EU

GHG intensity per kWh from electricity generation (gCO2eq / kWh El) at medium voltage

= (CO2 emissions per kWh from electricity generation) * (upstream emissions factor) * (correction for supply losses)*(correction for on-site losses)

where:

CO2 emissions per kWh from electricity generation = reported in the latest International Energy Agency (IEA) report "*CO2 Emissions from Fossil Fuel Combustion*" or based if possible on the grid area's latest National Inventory Report to IPCC.

Upstream emissions factor = 1.13; this takes into account upstream emissions

(Correction for supply losses) =

(gross production in TWh/year)

÷

[("gross production" in TWh/year) – ("own use" by power plants in TWh/year) – ("other use" in TWh/year) – ("transmission losses")*0.52]

(correction for on-site transmission losses) = 1.01

The data in this formula, for different countries, are in the latest IEA report "*Electricity Information*" (in the 2017 edition they are in table 1.1)[21].

The total transmission losses in "**Electricity Information**" are to low voltage consumption, but plants mostly use medium voltage electricity, which saves grid losses in low-voltage distribution. The fraction of the transmission (and distribution) losses which occur down to medium voltage is not available from IEA, therefore the average for EU should be assumed, which is 52%.

A2.4 Hierarchy of data sources for emissions intensities of minor inputs

The GHG intensity of "minor inputs" other than electricity are taken preferably from "Definition of input data to assess GHG default emissions from biofuels in EU legislation". (European Commission 2016). The same values are intended to be shown also in a revised version of the BIOGRACE tool22. If the emission intensity does not appear there, it may be taken first from the current version of the JEC-WTW report 9 as

[22] www.biograce.net/

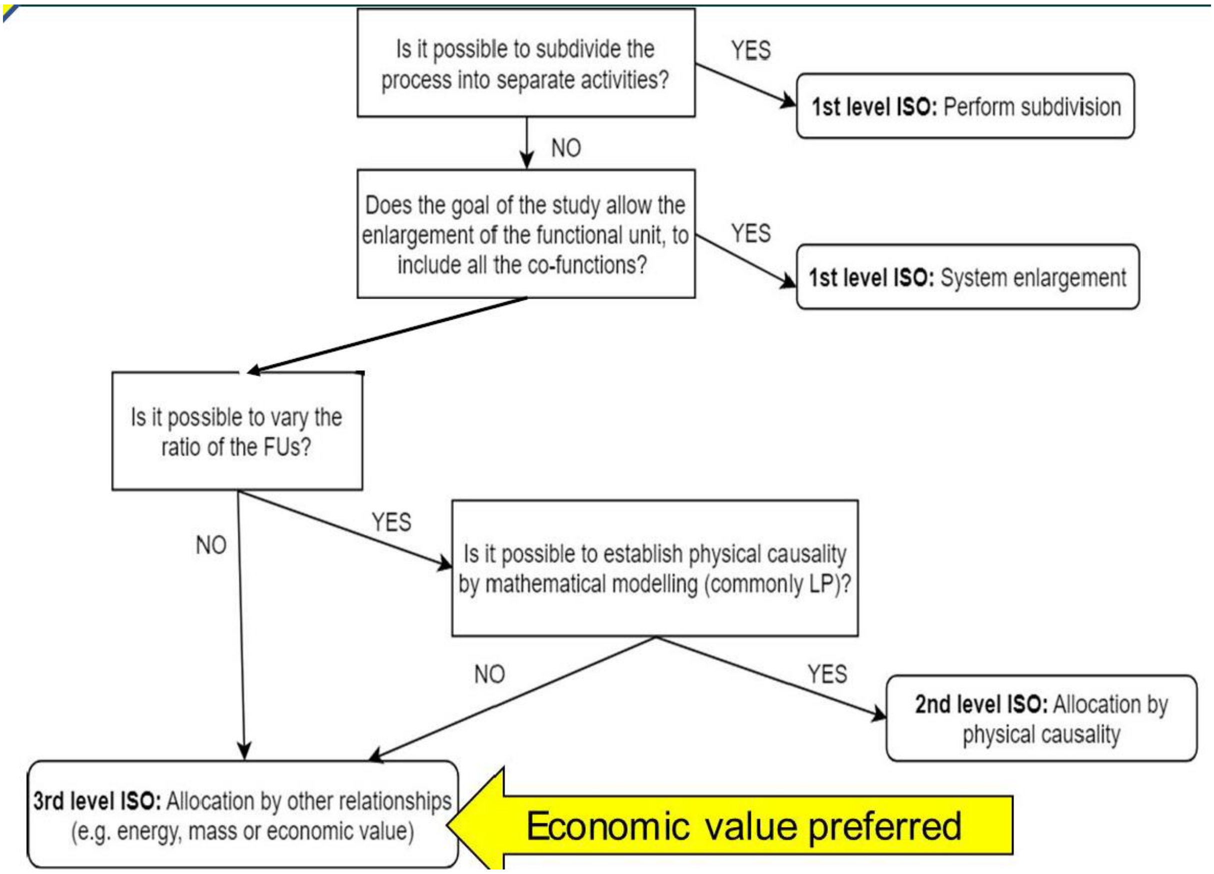
these are calculated from the same database), and if it does not appear there, from other independent LCA databases such as GEMIS, ECOINVENT, GABI, etc.

If there is no suitable value in independent LCA databases, the carbon intensity of the input shall be calculated using the same procedure as the emissions associated with products in section 5 of this document.

A2.5 Attribution of emissions to coproducts, for calculating emissions intensity of products used as elastic inputs to IF projects

A simplified version of the ISO 14044 (2006) multifunctionality framework is used.

Figure A2.1 Simplification of the ISO 14044 (2006) framework



The ISO 14044 framework is suitable for application to elastic inputs, but is not needed for rigid inputs or projects. The option of substitution has been eliminated in order to simplify calculations.

The most common misunderstanding of the ISO 14044 framework comes from the 2nd level "allocation by physical causality". That means establishing a causal connection between the emissions and the ratio of different products. In an industrial plant, a process model is generally required to show the emissions implications of increasing the output of just the product in question, without varying the quantity of other products produced. It is not the same as allocating using an arbitrary physical property of the products, which is at level 3 in the hierarchy.

In the third level of the ISO hierarchy, ISO is not very clear about how to select the "other relationship" for allocation. However, ISO 14041 (1998) has an annex that discusses the choice according to the “cause of the limit” of the function, or the motivation to run the factory. For example, in the case of goods transported by truck transport, the limit on the amount of goods transported is often the weight of the cargo. So in this case, allocation by weight of the different goods can be justified. But more frequently in an industrial process, the motivation for making different products is the market value of the products. So, at this 3rd level of the ISO hierarchy, allocation by the economic value of the products is the correct choice. In fact, it works also for truck transport, because the cost generally depends on the weight, if that is the “cause of limit” of how much the truck can carry.

The point in the supply chain where the allocation is applied shall be at the output of the process that produces the co-products. The emissions allocated shall include the emissions from the process itself, as well as the emissions attributed to inputs to the process.

A2.6 Processes with a fixed ratio of outputs: definition of rigid, elastic and semi-elastic products

Some inputs may be products of processes that produce a fixed ratio of outputs. An example of such a process is the chlor-alkali process, which produces sodium hydroxide, chlorine and hydrogen in a ratio that is fixed by stoichiometry. Here, we consider the case where all three are sold as inputs to a process in IF[23].

This annex presents a quantitative way to find if the supply of such an input is rigid, elastic or a mix of the two.

Consider a process that produces various outputs (products, by-products, residues or wastes) in fixed ratios and with different prices. The incentive for a company to increase the production of the whole plant is proportional the sum of the economic value of all the outputs; the fraction of the incentive from one output is proportional to its value-fraction in the total value of products produced by the plant. We call the fraction of the incentive from one output the “elasticity parameter” for that output.

For example, if one output is a waste with zero value, there is no incentive to increase overall production to supply more of it. In that case the output has a rigid supply, and the elasticity parameter is zero. At the opposite extreme, if the process only has one output, then it represents the entire incentive to increase production, so the supply of that output will increase with demand, its supply is perfectly elastic.

Therefore we propose to reduce the administrative burden of the calculation by the following simplification:

– A product that represents less than 10% of the value of the total products of the supplier are treated as perfectly rigid, and their emissions calculated accordingly.

– A product that represents more than 50% of the total value of the products of the supplier are treated as perfectly elastic, and their emissions calculated accordingly.

[23] By contrast, if the hydrogen is not sold, but is being burnt for process heat, then the emissions of the plant are obviously only attributed to sodium hydroxide, chlorine. If it is then proposed to start selling the hydrogen, replacing the process heat with natural gas, the hydrogen is a rigid source, and its emissions are given by those of the natural gas that replaces it.

– The emissions attributed to a product that represent between 10% and 50% of the total value of the products of the production process shall be:

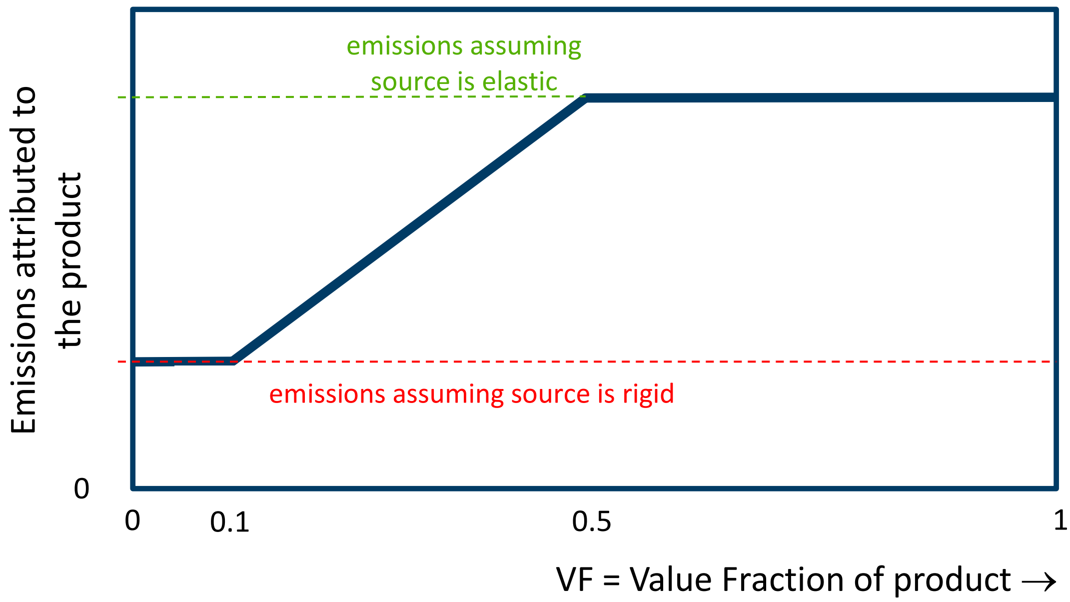
$$\frac{(\text{emissions assuming elastic source})*(VF-0.1)+(\text{emissions assuming rigid source})*(0.5-VF)}{(0.5-0.1)}$$

…where VF = Value Fraction

= (value of the product)/(total value of all products produced by the process)

This relation is represented in the following graph (note: this graph is only schematic; the emissions calculated assuming the result is elastic are not necessarily higher than those assuming that it is rigid, and calculated emissions can also be negative)

Figure A2.2 Determining emissions for semi-elastic inputs



In practice, we expect the great majority of inputs to fall into either the “elastic or “rigid category, so the simplification is considerable in most cases. The continuous relationship avoids the legislative problems that would arise if there would be no proportional range, but instead a step change in the calculation method at a single threshold of VP. In this case, some input streams could change dramatically in emissions intensity, depending on the exact price that is taken. With the proposed system, the price taken is much less critical to the result. The prices should be the average of the data for the last 3 years.

The reason the figure is not symmetrical is that we have the precedent of the REDII, where, for example, the supply of crops for biofuels is treated as purely elastic, whereas in practice some of the crop input for biofuel is diverted from other uses.

Annex 3 Energy Storage Equations

Table A3.1 shows the methodologies to be used to calculate GHG savings for the various purposes of storage technologies for Methodology 3. The key issues are (a) which form of energy charges the storage; and (b) which form of energy is released when the storage discharges. This is because the greenhouse gas emissions during charging and discharging are influenced in the respective sectors concerned. In simple terms, we look at what additional emissions are caused by charging the storage and what emissions are saved by discharging.

Table A3.1 Formulas used for the calculation of GHG emission avoidance of energy storage projects according to Methodology 3 (sensible simplification)

Annual GHG savings =	Discharging emissions avoidance	–	Charging emissions
Eq. 1.a [Power-to-Power]	$StorEff * EC_y * MEF_{r,y}$	–	$(EC_y - EC_{y,zero}) * MEF_{r,y}$
Eq. 1.b [Power-to-Heat]	$ConvEff * StorEff * EC_y * EF_{ETS\ heat}$	–	$(EC_y - EC_{y,zero}) * MEF_{r,y}$
Eq. 1.c [Power-to-H2]	$ConvEff * StorEff * EC_y * EF_{ETS\ H2}$	–	$(EC_y - EC_{y,zero}) * MEF_{r,y}$
Eq. 1.d [Power-to-Gas]	$ConvEff * StorEff * EC_y * EF_{NaturalGas}$	–	$(EC_y - EC_{y,zero}) * MEF_{r,y}$
Eq. 1.e [Power-to-Liquid]	$ConvEff * StorEff * EC_y * EF_{Oil}$	–	$(EC_y - EC_{y,zero}) * MEF_{r,y}$
Eq. 1.f [H2-to-Power]	$ConvEff * StorEff * EC_y * MEF_{region,y}$	–	$EC_y * EF_{H2\ source,y}$
Eq. 1.g [H2-to-Heat]	$ConvEff * StorEff * EC_y * EF_{ETS\ heat}$	–	$EC_y * EF_{H2\ source,y}$
Eq. 1.h [H2-to-H2]	$StorEff * EC_y * EF_{ETS\ H2}$	–	$EC_y * EF_{H2\ source,y}$
Eq. 1.i [H2-to-Gas]	$ConvEff * StorEff * EC_y * EF_{NaturalGas}$	–	$EC_y * EF_{H2\ source,y}$
Eq. 1.j [H2-to-Liquid]	$ConvEff * StorEff * EC_y * EF_{Oil}$	–	$EC_y * EF_{H2\ source,y}$
Eq. 1.k [Heat-to-Heat]	$StorEff * EC_y * EF_{ETS\ heat}$	–	$EC_y * EF_{heat\ source,y}$

ConvEff = conversion efficiency;StorEff = storage efficiency; EC_y *= total energy charged in year y;* $EC_{y,zero}$ *= energy charged for grid purposes or from additional renewable electricity in year y;* $MEF_{r,y}$ *= mean or marginal emission factor of electricity in region r in year y;* $EF_{ETS\ heat/H2}$ *= emission factor based on ETS benchmarks for heat/hydrogen production;* $EF_{natural\ gas/oil}$ *= mean emission factor for natural gas/oil;* $EF_{heat/H2\ source,y}$ *= emission factor for heat/hydrogen source in year y to be provided by project proponent*